MACHINERY.

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AN EXPERIMENTAL GAS TURBINE.

DR. ALFRED GRADENWITZ.

It is a natural outcome of modern gas engine construction on one side, and the development of steam turbine building on the other, that endeavors should be made to combine the advantages inherent in both these rivals of the reciprocating steam engine.

The principle of a hot air turbine was enunciated as far back as 1853 by F. Redtenbacher in his book on the "Caloric Engine," where attention is drawn to the fact that a turbine would be an ideal motor to be propelled by hot air, as any difficulty resulting from unequal expansion of the parts would be done away with. The enormous speed of revolution necessary in a gas turbine, however, led him to think that a constructive realization of his idea would be impossible. Meantime, methods of gas engine construction have been immensely improved upon, while in designing steam turbines means of reducing the speed to suitable limits by dividing the pressure into steps have been found out, so that obstacles that were formerly insurmountable do not now present serious difficulties. The moment seems to have come for a successful gas turbine to be designed, and some solutions of the problem are now being attempted.

An interesting type of gas turbine, the so-called "fire-turbine," due to Dr. F. Stolze of Berlin-Charlottenburg, is attracting much attention at the present day, and it is fair to state that the inventor of this engine enunciated the principle of dividing the pressure into steps with a view to diminishing the speed in his first description of this turbine more than thirty years ago, at which time, however, patents were refused him by the Prussian Patent Office on account of the special conditions then attached to patenting. The matter was again taken up later on, when patents were readily granted both for the original invention and subsequent additions to the same. Although the realization of the idea might have been difficult to carry out at the time of its being first conceived, there are no such difficulties in the way now and the experimental plant of 200 horse power, illustrated in Fig. 2, is nearing completion.

The underlying principle consists in compressing the atmospheric air to a moderate tension—say 1½ atmospheres above atmospheric pressure—and in afterward heating this compressed air so that it will assume a volume 2 or 2½ times as great at the same tension. After this the air is allowed to expand again to atmospheric pressure, while passing through the passages of the turbine. The energy available for doing work upon the vanes of the turbine, is due to the increase in volume resulting from the heating of the air. The process is carried out as follows: By means of a compression system consisting of ten turbine wheels or runners arranged one behind another on a conical drum, atmospheric air at a temperature of, say, 15 degrees C. is compressed adiabatically until a point is reached where its pressure is equivalent to that of 2½ atmospheres. During this process, its temperature rises by 103 degrees C., leaving 282 degrees C. to be provided for by the heat of the furnace in order to bring the air up to the required temperature of 400 degrees C. This is the highest figure to which it can be brought without exceeding the heat limit of the present-day boiler, though patents have recently been applied for to cover a device which, it is claimed, will enable the temperature to be raised to 1,500 degrees C., or even higher, without altering the construction of the boiler, thus increasing the efficiency of the motor ten-fold without increasing its dimensions. The furnace used consists of a cylinder lined with chamotte and separated by a ring of air from the furnace walls. The combustion of the coal is brought about by means of a part of the compressed air passing through the grate, and the carbon monoxide thus formed is converted into carbon dioxide on issuing into the surrounding ring-shaped space, which contains the remainder of the compressed air, as yet only partially heated. By a special regulation device, the supply of compressed air is so controlled as to maintain a constant temperature of 400 degrees C. The compressed air, having been mixed with the heated gases, now streams toward the expansion system, which comprises the turbine, and is mounted on the same axle as the compression system. In passing through the expansion system the compressed air is expanded down to one atmosphere, during which process it cools to 243 degrees C. In order to avoid wasting the heat contained in the exhausted gases at this high temperature, they are now conducted through a tubular heater which is

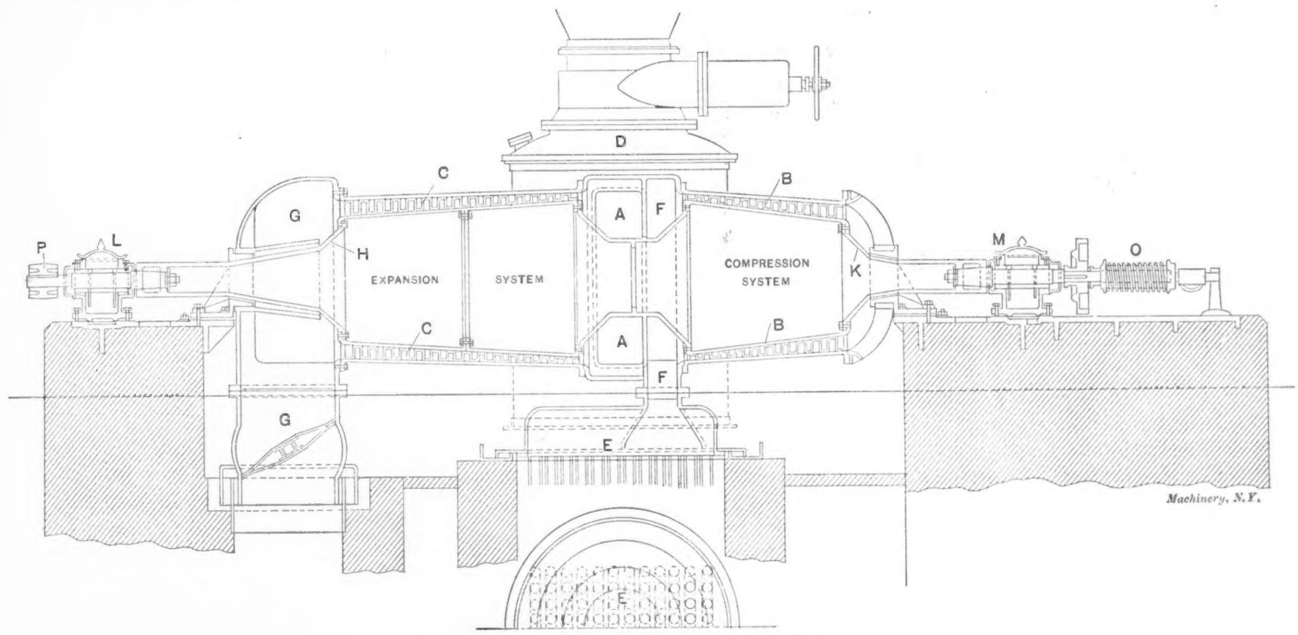


Fig. 1. Showing Principle of a Hot Air Turbine.

A great deal of attention is now being given to the question of the gas turbine, both in this country and in Europe. Although much experimental work has been carried on, the apparatus of Dr. Stolze, described in this article, is the first to be so far perfected as to attract the attention of engineers generally. While his work has not progressed so far as to enable one to predict whether he will achieve success in his endeavors, his apparatus is of unusual interest because it is a pioneer in what is destined to be an important field.

located between the compression system and the furnace. The exhausted gases therefore raise the temperature of the compressed air during its passage from the compression system to the furnace. As stated above, the air when leaving the compressor has a temperature of 118 degrees C., which is raised to about 180 degrees C. in the heater before it reaches the furnace. It therefore remains for the furnace to raise the temperature of the air by only 220 degrees in order to reach the initial temperature of 400 degrees, at which the air and gases pass to the turbine.

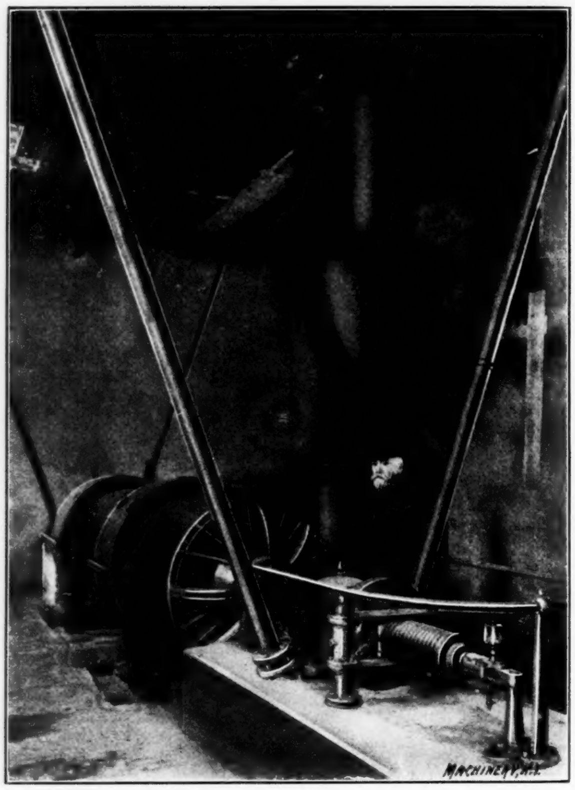


Fig. 2. Two-hundred H. P. Experimental Plant.

In Fig. 3 is a diagrammatic sketch of Dr. Stolze's invention, showing in outline the arrangement of the compression and expansion systems comprising respectively the air compressor and the turbine motor. In casing *A* on shaft *I* is seen a set of "fire-turbines." The outlet of *A* is at *C*, and the inlet (not shown in the sketch) at the opposite end of the turbine set. On the same shaft is placed a larger set of turbines in casing *B*, which has an inlet at *E* and an outlet at the opposite end. The two pipes *C* and *E* communicate with the heating device,

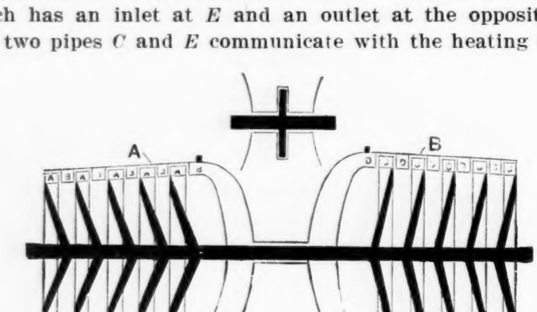


Fig. 3.

whereby the temperature of the motor fluid can be raised. The apparatus is operated as follows: Shaft *I* is made to rotate in the direction of the outer ends of the turbine blades in *A*. The set of turbines in casing *A* will then draw in the air, compress it, and finally deliver it in the compressed state through *C* to the gas producer or any other calorific medium provided. The gases generated in the producer pass in the heated state through *E* into *B*, where their motive force is utilized by the turbines. The energy developed in the larger casing, *B*, will obviously exceed the energy required to draw the cold air into *A*, so that the apparatus becomes self-driving, developing energy for motive power. *aa*, etc., are the vanes of the rotating elements of the compressor, and *bb* the stationary guide vanes; *cc*, etc., are the moving vanes of the turbine motor, and *dd*, etc., are the guide vanes. If desired, the expansion and compression systems may be duplicated, which will be found useful to avoid end thrust on the shaft. To prevent the direct passage of air from *A* to *B*, the device shown diagrammatically in the upper part of Fig. 3 may be made use of. This consists of an annular casing on the hollow tube through which the shaft passes, fitting close to a disk on the shaft. The disk may be grooved or scored to prevent the flow of air over its surface. It is interesting to note the similarity of this device, designed thirty years ago, to the device of the labyrinth used by Parsons in the construction of his turbine.

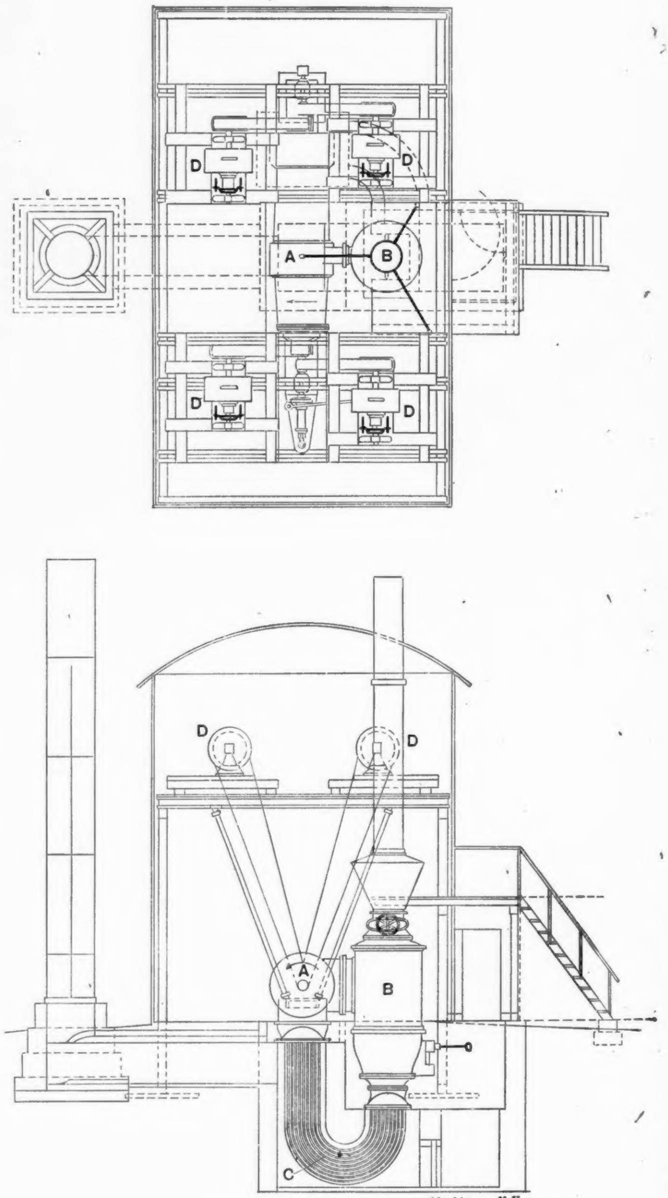


Fig. 4. Sectional Elevation and Plan of Plant.

In consequence of friction between the fuel particles, it might happen that considerable reaction or back pressure would be produced, retarding the motion of the heating gases and air, and to some extent preventing perfect combustion. This possibility is eliminated by either of the two devices shown in Figs. 5 and 6, whereby the supply of combustible gases and compressed air is so arranged that they flow into the mixing chamber in the same direction, and each of the two currents has a tendency to draw the other along with itself. Back pressure is thus avoided. In these cuts *A* is the furnace, *B* the mixing chamber for the combustible gases and compressed air, *N* the place where the combustion of the carbonic oxide gas occurs, *M* a funnel through which fuel is supplied, *V*

the grate, C the passage for the compressed air from the compression turbine, D the passage for the compressed air into the mixing chamber, E the passage for the supply of air to the furnace, while F and G show the method of introducing gases and air in parallel directions.

Figs. 1 and 4 show more completely the arrangement of the hot air turbine, and of the plant containing it. In Fig. 1 the apparatus is seen, consisting of a large shell in the form of a double cone, one end of which is the expansion or motor end and the other end, K, comprises the compression part. On the compression end is a series of rings of vanes attached to the drum and alternating with stationary rings of vanes. On the other end are similar vanes, comprising the expansion system. The air is drawn in through the passage between the vanes indicated at BB, and is delivered to the chamber FF from which it passes through the tubular heater E to the furnace D. It then enters the annular space, AA, and passes through the passage between the vanes CC to the exhaust chamber, GG, and thence to the tubes of the heater, E. L M are the bearings at the two ends, O is the governor, and P the pulley from which power is taken off the belt.

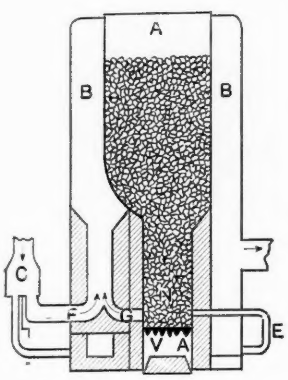


Fig. 5.

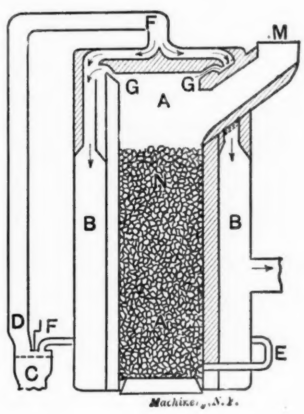


Fig. 6.

In Fig. 4 appears a sectional elevation and a plan of the whole plant. A is the turbine and compressor, B the furnace, C the heater, and DD the electric generator driven by the turbine.

One of the principal advantages of hot air turbines over steam turbines is their relatively low speed of revolution, at most 2,000 revolutions per minute with a maximum diameter of 1 meter. The main advantages, however, are that every bit of fuel consumed is utilized for power generated, no heat of escaping exhaust gases being lost, and that the air does not require previous vaporization as does water, an important item when we consider that to produce 1 kilogram of steam at atmospheric pressure consumes over 600 calories, while yet further heat is needed to induce working energy in the steam. It is claimed that the 200 horse power motor now in course of construction will insure a saving in the fuel consumed as high as 33 1-3 per cent. of that used in a steam engine plant.

* * *

We recently published a note in regard to the use of compressed air for maintaining water pressure where there was no available head of water. Our attention has since been drawn to an installation of the Acme Water Storage & Construction Company at the St. Louis Fair, which operates on this principle and is intended to make possible a constant supply of water under high pressure, thus displacing water towers and elevated tanks. The apparatus consists of two tanks, an air compressor, and a pump. One tank is kept constantly charged with air at a high pressure, while the second contains both air and water, the water being forced in by a pump, and the air being admitted from the first tank by a pressure reducing valve set to give constant pressure. As the water is pumped into the water tank, the air is removed by the compressor and returned to the air tank, so the pressure is always uniform. It is only necessary to run the compressor and pump when charging the system, for the apparatus is so arranged that the entire contents of the water tank may be used under a constant pressure before charging again. The Deane vertical pump was used with the apparatus exhibited.

VARIABLE SPEED MOTORS.—8.

THE STOW MULTI-SPEED MOTORS.

WM. BAXTER, JR.

In previous articles we have explained several methods for varying the speed of motors by varying the strength of the magnetic field in which the armature rotates. In all these arrangements the field strength is varied by electrical means, that is, by varying the strength of the magnetizing current that passes through the shunt field coils. It is possible, however, to vary the strength of the motor field by mechanical means, and this is the method employed in the Stow multi-speed motors.

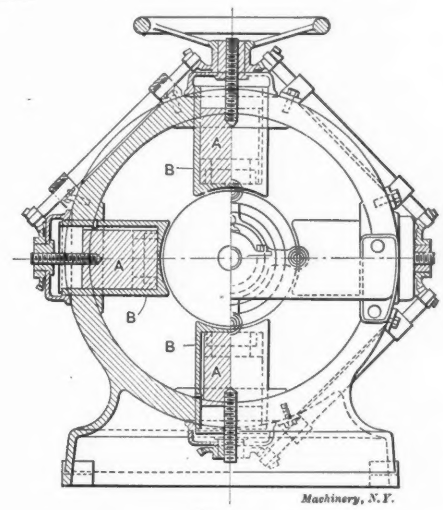


Fig. 1.

The mechanical method of varying the strength of the motor field complicates the construction somewhat, but on the other hand it increases the range of speed variation obtainable with a motor of a given size; that is, this result is obtained if the construction is such as is used in the Stow motors. A brief explanation of the principles involved in obtaining speed variation by means of changes in the field strength will serve to make the matter clear.

Principles of Commutation.

For a motor to run without injurious sparking at the commutator it is necessary that the strength of the motor field be sufficient to counteract the effect of the armature reaction. In a two-pole motor the current flows through the armature

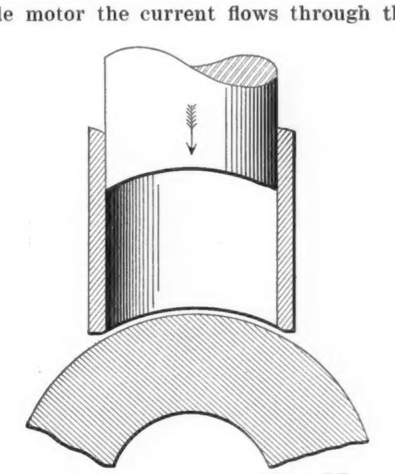


Fig. 2.

coils in one direction while they are passing through one-half of the revolution, and in the opposite direction while passing through the other half. At the instant when a commutator segment passes under the brush, the current flowing in the coil connected with this segment and the one back of it, must reverse its direction. To accomplish this result the field magnetism at this point must be in the right direction to induce a reverse current, and of proper strength to develop a current equal to that flowing in the other coils. If this is done there will be no sparking at the brushes. If a motor runs with a uniform load, and at a uniform speed, there is no difficulty in

accomplishing this result, but if the load varies the reaction of the armature will vary and if the speed varies it must be produced by a variation in the field strength, and both these actions will result in disturbing what we might call the commutation balance, so that sparkless operation cannot be obtained. In practice, a considerable variation in the field strength can be obtained without producing a noticeable increase in the sparking, but with the standard designs of stationary motors this variation is seldom more than 20 or 30 per cent. To obtain a speed variation of say two to one by means of field strength variation obtained by varying the strength of the field magnetizing current, it is necessary to make the motor considerably larger than for constant speed work, so that the armature may be reduced and the field increased. This change reduces the relative effect of the armature reaction, so that when the field strength is varied, its direction is not materially changed, and as a consequence the sparking at the brushes is not increased.

Perfect commutation does not depend upon maintaining the strength of the magnetic field within proper limits over the entire surface of the poles, but only over that portion that the armature coils pass through while the act of commutation is

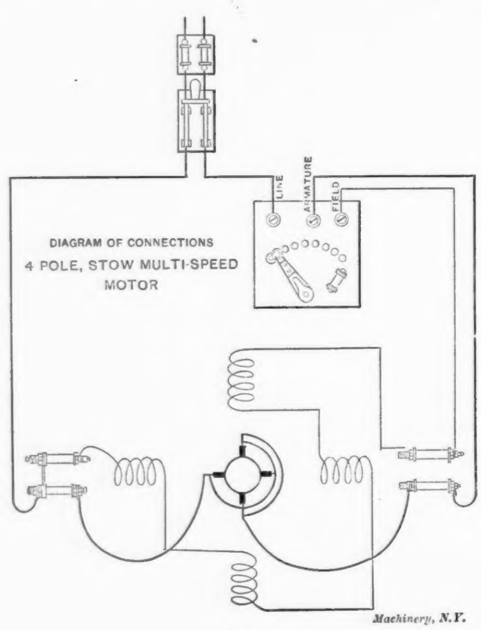


Fig. 3.

taking place; in other words, over the portion through which the coils pass as they are short-circuited by the commutator brushes. This portion of the magnetic field is developed by the edges of the pole pieces, so that if at these points the magnetism can be kept practically constant it matters little how much it may vary over the balance of the pole surface.

When the field is varied by varying the strength of the magnetizing current, the strength of the magnetic field varies alike over the whole of the polar surface, hence, only a comparatively small change can be effected in the magnetic density before the commutator brushes begin to spark badly.

Mechanical Method of Varying the Field Strength.

The strength of the field of a motor is varied mechanically by varying the distance between the surface of the poles and the surface of the armature core. This variation in the distance between the surfaces of the two parts varies the field strength, owing to the fact that iron does not resist being magnetized as much as air, or as it is commonly stated, the magnetic reluctance of iron is much lower than that of air. If the poles are drawn away from the armature the strength of the magnetic field is reduced. The reduction, however, will be uniform over the whole polar surface. This method of varying the field strength was embodied in several designs of motors made in the early days of electrical development, but it did not survive, owing to the fact that it produces precisely the same result as is obtained by varying the strength of the magnetizing current and has no advantage to offer to offset the increased cost of making the motor.

Principle of the Stow Multi-speed Motor.

The Stow multi-speed motor is constructed upon a modification of this principle which, while apparently small, produces decidedly different results.

A clear understanding of the construction of this motor can be obtained from Fig. 1, which is a sectional vertical elevation at right angles to the shaft. The poles of the motor are

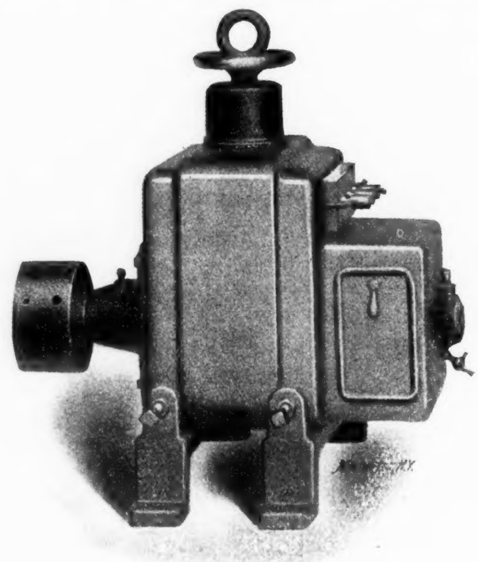


Fig. 5.

made up of a stationary shell, *B*, and a movable core, *A*, both parts being made of iron. The cores *A* of the several poles are moved in a radial direction by means of the handwheel seen at the top, and the miter gear connections, so that all the cores move equally. When the cores are in the closest position to the armature, the air space is reduced to the minimum point, and as a consequence the field strength is the greatest.

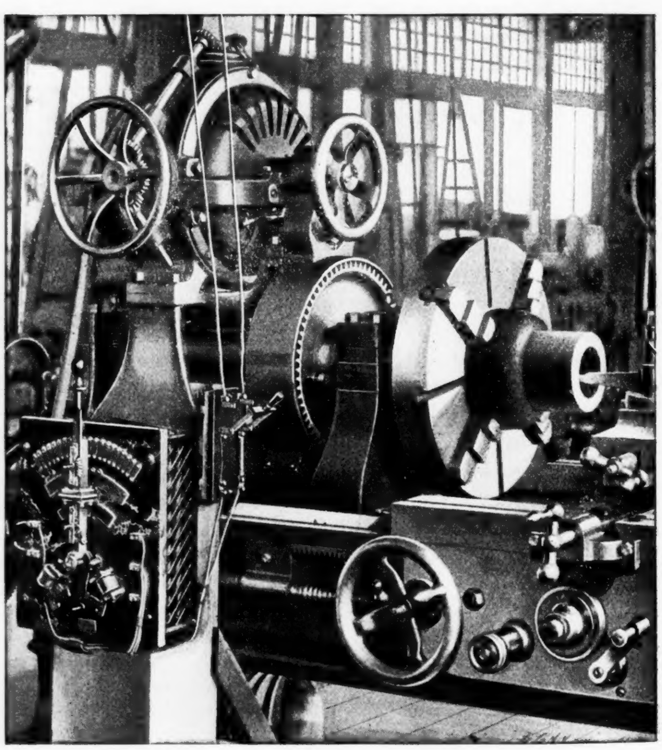


Fig. 4.

As the cores *A* are withdrawn from the armature, the length of air interposed in the magnetic path is increased, and as a result the strength of the magnetism is reduced. When the cores are withdrawn as far as they will go, the magnetic field is reduced to the lowest point. From this it will be seen that by varying the position of the cores *A*. the strength of the field is varied, and thereby the speed of the motor is changed.

It will be noticed in Fig. 1 that at all times the distance between the end of the outer casing, *B*, and the armature remains the same; hence, the resistance to the flow of magnetism along this path remains unchanged, and as the magnetizing current also remains unchanged, the magnetic strength of the field between the armature and the end of casing *B* does not vary to any appreciable extent. It is this magnetism that acts upon the armature coils when they are passing under the brushes, and are undergoing commutation;

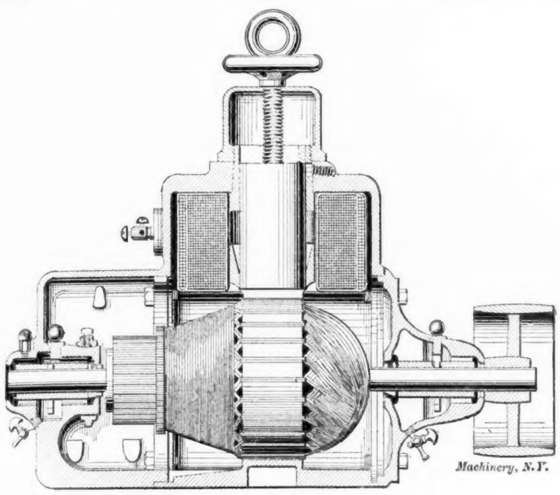


Fig. 6.

therefore, the act of commutation is as perfectly performed when the cores *A* are far removed from the armature, as when they are near by. In fact, the changing of the position of these cores only changes the strength of the magnetism flowing from the central portion of the pole surface, and thus varies the total amount of magnetism acting on the armature, and thereby the speed of the latter, but without interfering with the sparkless operation of the brushes. The practical result of this action is that a motor of a given design can be made to vary its velocity through a much wider range than if the variation were obtained by changing the strength of the field magnetizing current.

Speed Variation of Motors.

The average stationary motor, not intended for variable speed work, will not run well at the brushes if the speed is varied much above 30 per cent.; but a machine of the same size and electrical proportions, if provided with the movable cores *A* can vary its velocity in the ratio of 2½ to 1 without injurious sparking at the commutator. To obtain this same range of speed variation by varying the strength of the field

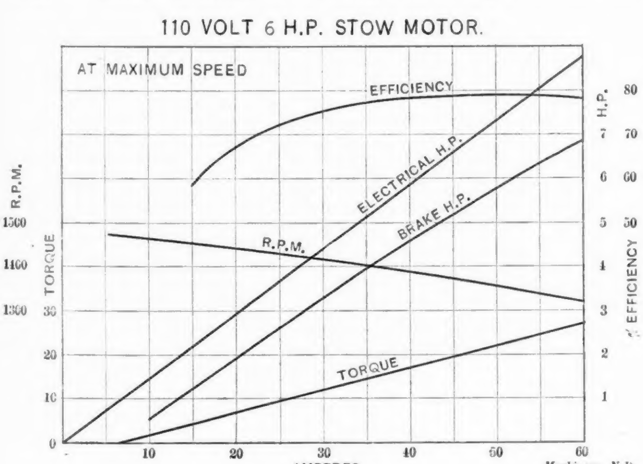


Fig. 7.

current it would be necessary to make the motor much larger.

Thus it will be seen that the effect of the Stow construction is to increase the range of speed variation without increasing the size of the motor.

Modifications in the Construction of the Movable Cores.

In Fig. 1 the cores *A*, when in the position nearest to the armature, are some distance away from the pole surface, the casings *B* being constructed with a thin bottom which forms the actual polar face. In some of these motors, however, the cores *A* project through the end of the casings *B* so as to come flush with their inner ends, as shown in Fig. 2.

Motor Starter.

As already explained, the Stow multi-speed motor owes its speed variation to changes in the reluctance of the magnetic circuit. The electrical circuits remain unchanged under all conditions and hence no electrical controller, rheostat, or circuit-changing device is required to vary the speed. A simple motor starter, such as is used with constant-speed stationary motors, is all that is required; the connection with the starter, the line wires and the motor for a four-pole motor, being as shown in Fig. 3. For operation with machines that have to be driven in opposite directions, a reversing motor starter is required, as shown in Fig. 4, which shows a Stow motor mounted upon a lathe, and provided with a reversing motor starter.

Bi-polar Stow Multi-speed Motors.

Multi-speed motors are made of the bi-polar, as well as the multi-polar type. Fig. 5 shows the external appearance of a bi-polar machine. With this type of motor no miter wheel gearing is used for connecting the movable pole cores. The gearing is dispensed with by constructing the motor so that there is only one movable core. The construction is clearly shown in Fig. 6, which is a vertical sectional view of Fig. 5 taken parallel with the shaft.

Efficiency of the Stow Motor.

There is nothing in the construction of these motors that can prevent them from being just as efficient as those in which

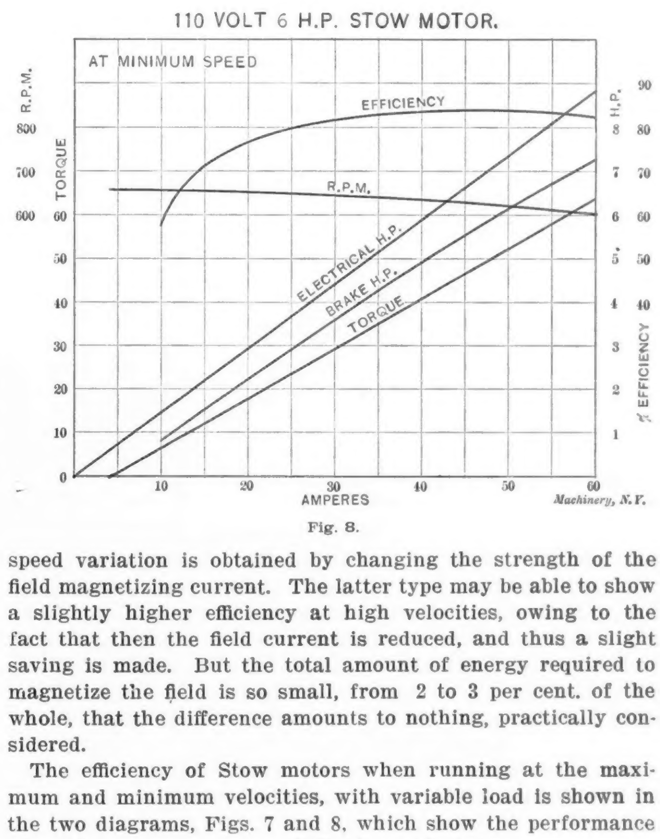


Fig. 8.

speed variation is obtained by changing the strength of the field magnetizing current. The latter type may be able to show a slightly higher efficiency at high velocities, owing to the fact that then the field current is reduced, and thus a slight saving is made. But the total amount of energy required to magnetize the field is so small, from 2 to 3 per cent. of the whole, that the difference amounts to nothing, practically considered.

The efficiency of Stow motors when running at the maximum and minimum velocities, with variable load is shown in the two diagrams, Figs. 7 and 8, which show the performance of a 6-horse-power motor of the four-pole type.

The advantages claimed for the Stow multi-speed motor are: That it gives a speed variation of 2½ to 1 with a machine of a given size, which, if wound for the same horse power, and arranged to vary the speed by varying the strength of the field magnetizing current, would not give a speed variation much more than half as great; that practically the same power is given at all speeds; that the same efficiency is obtained at all velocities; that the speed remains unchanged when the load changes (this result being accomplished owing to the fact that no armature resistance is used to vary the speed); and, finally, that an infinite number of speeds can be obtained between the highest and the lowest, this being due to the fact that the cores *A* can be moved to an infinite number of positions.

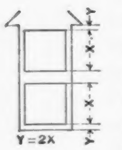
DIRECTIONS FOR DRAWING D. C. COILS.

OSCAR STEGEMAN.

Example: Armature Connected Straight.

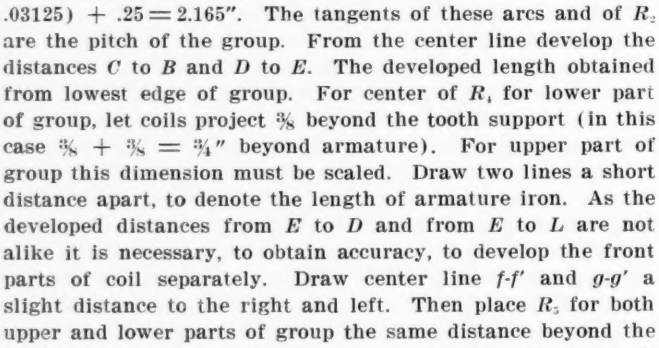
Given: 44 slots, 132 coils, each coil consisting of one turn 1/8 inch by 1/2 inch copper. Wind No. 1 to No. 12; connect No. 1 to No. 2. 1-32 inch clearance between insulated groups. Insulation per group equals 4 × .018 = .072 inch. This allows for shellac, etc.

Solution. Draw a semicircle with a radius equal to that of the armature. Divide this semi-circle into half as many parts as there are number of slots in armature. Let the distance from point *A* on center line to slots Nos. 1 and 12 be equal. Draw the bare groups of coils in slots as in sketch, $Y = 2X$. Then draw the rear view; the part *B-C* as an arc of a circle



with the armature center as the center for the radius. Draw the part *D-E* straight to the right from *D* until its runs tangent to an arc of a circle with a radius whose center is on a line running through center of armature and center line of slot No. 12. The distance from *C* to *D* is equal to twice the radius R_1, plus width of copper strap.

Then on the plan view draw center line *a a'*, this being the center line for the bending pin for bending rear end of coil. This line also to run through center of R_2. For the pitch of the coils, set off from center line of R_2 "*n*" number of equal parts—the length of these parts equal to the distance between two slots projected on lower edge of respective groups. In this case set off $b\ c = 4$ (*F-G*); *F-G* equal to projection of 2 slots projected on lower edges of *B-C*. $b'\ c' = 4$ (*H-I*) *H-I* equal to projection of two slots projected on lower edge of *D-E*. Take *c* and *c'* as centers for arcs of circles with radii (R_3) = *n* (thickness of group + insulation + clearance between insulated groups) + R_2. In this case 4 (.375 + .072 + .03125) + .25 = 2.165". The tangents of these arcs and of R_2 are the pitch of the group. From the center line develop the distances *C* to *B* and *D* to *E*. The developed length obtained from lowest edge of group. For center of R_4 for lower part of group, let coils project 3/8 beyond the tooth support (in this case 3/8 + 3/8 = 3/4" beyond armature). For upper part of group this dimension must be scaled. Draw two lines a short distance apart, to denote the length of armature iron. As the developed distances from *E* to *D* and from *E* to *L* are not alike it is necessary, to obtain accuracy, to develop the front parts of coil separately. Draw center line *f-f'* and *g-g'* a slight distance to the right and left. Then place R_5 for both upper and lower parts of group the same distance beyond the tooth support as R_4 for the lower part of group. Then set off from *d* to *e* the same distance as from *b* to *c*. From *d'* to *e'* set off the same number of spaces as from *b'* to *c'* using the

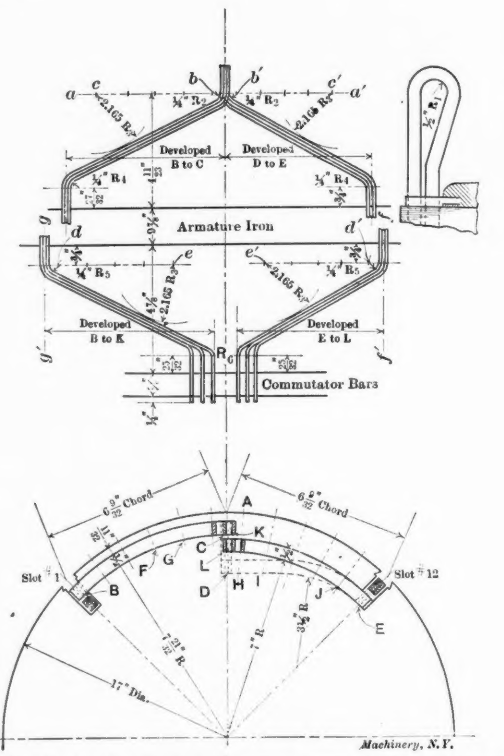


Example of Armature Details.

distance *E-J* instead of *H-I*. With *e* and *e'* as centers draw arcs of circles with R_3 as a radius. The tangents of these arcs and of R_5 are the pitch of the group for the front part of coil. To determine center of R_6 and also developed distance *B* to *K* and *E* to *L*, a few trials are necessary. Draw an arc of a circle from *B* to *K* with armature center as center for radius. Likewise from *E* to *L*. Center of R_6 should be 3/4 inch from edge of commutator bars. This is obtained by moving the ends of coils to the right or left until the developed distance from *B* to *K* and from *E* to *L* are such as will bring center of both R_6 on exactly the same line. Then draw the commutator bars 3/4 inch further on and let the coils extend 1/4 beyond. The distance from coil No. 1 to coil No. 2 is a space set off on the armature circumference equal to 1-3 of the distance from center line of one slot to center line of the next. After the plan view has been finished the end view is to be completed. Draw in the ends of coils and give dimensions, except R_3, as shown in diagram. These dimensions are all to be scaled from the drawing, and are sufficient for making a former.

Example: Armature Connected Cross.

Given: 44 slots, 132 coils, each coil consisting of one turn 1/8 inch by 1/2 inch copper. Wind No. 1 to No. 12. Connect No. 1 to No. 67. 1-32 inch clearance between insulated groups. Insulation per group = 4 × .018 = .072 inch. This allows for shellac, etc.



Method of Laying Out D. C. Coil Forms. Barrel Winding Armature Connected Straight.

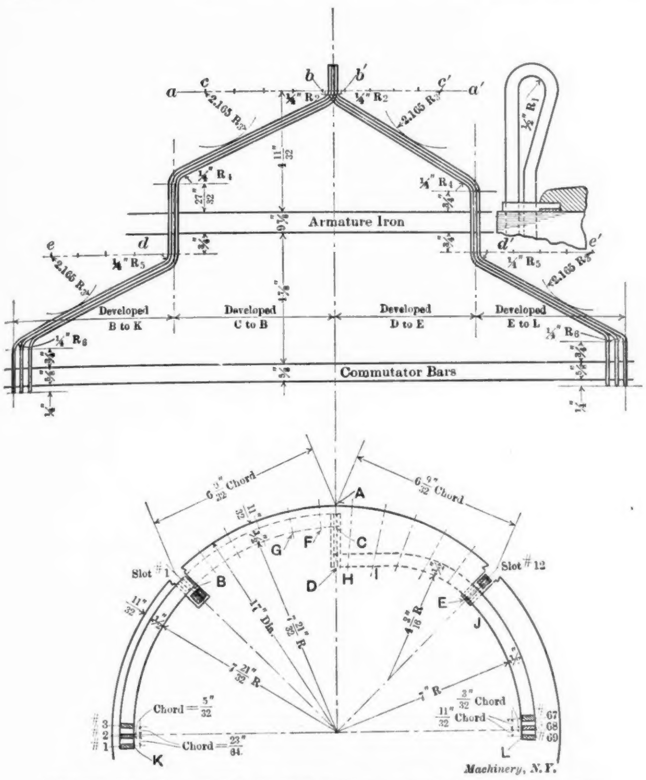
Solution. Draw a semi-circle with a radius equal to that of the armature. Divide this semi-circle into half as many parts as there are number of slots in armature, and let the distance from point *A* on center line to slots Nos. 1 and 12 be equal. Draw bare groups of coils in slots as in small sketch. $X = 2Y$. Then draw the rear view, the part *B-C* as an arc of a circle with the armature center as the center for the radius. Draw the part *D-E* straight to the right from *D* until it runs tangent to an arc of a circle with a radius whose center is on a line running through center of armature and center line of slot No. 12. The distance from *C* to *D* is equal to twice the radius R_1 + width of copper strap.

Then on the plan view draw center line, *a-a'*, this being the center line for the bending pin for bending rear end of coil. This line also to run through center of R_2. For the pitch of the coils, set off from center of R_2 "*n*" number of equal parts, the length of these parts equal to the distance between two slots projected on lower edge of respective groups. (In this case set off $b\text{-}c = 4$ (*F-G*), *F-G* equal to a projection of two slots projected on lower edge of *B-C*. And $b'\text{-}c' = 4$ (*H-I*) *H* equal to a projection of two slots projected on lower edge of *D-E*. Take *c* and *c'* as centers for arcs of circles with radii (R_3) = *n* (thickness of group + insulation + clearance between insulated groups) + R_2. In this case 4 (.375 inch + .072 inch + .03125 inch + .25 inch = 2.165". The tangents of these arcs and of R_2 are the pitch of the group. From the center line develop the distances *C* to *B* and *D* to *E*. The developed length obtained from lowest edge of group. For center of R_4 for lower part of group, let coils project 3/8 beyond the tooth support (in this case 3/8 + 3/8 = 3/4" beyond armature).

*This article may be properly considered a part of the data sheet contributed by Mr. Stegeman this month, and is published in the reading columns so that it may appear in the same number with the data sheet.

For upper part of group this dimension must then be scaled. Draw two lines a short distance apart, to denote the length of armature iron. Then place R_5, for both upper and lower part of group, the same distance beyond the tooth support as R_4 for the lower part of group. Then set off from *d* to *e* the same distance as from *b* to *c*. From *d'* to *e'* set off the same number of spaces as from *b'* to *c'*, using the distance *E-J* instead of *H-I*.

With *e* and *e'* as centers, draw arcs of circles with R_3 as a radius. The tangents of these arcs and of R_5 are the pitch of the group for the front part of coil. To determine center of R_6 and also developed distance *B* to *K* and *E* to *L*, a few trials are necessary. Draw an arc of a circle from *B* to *K*, with armature center as center for radius. Likewise from *E* to *L*. Center of R_6 should be 3/4 inch from edge



Method of Laying Out D. C. Coil Forms. Barrel Winding Armature Connected Cross.

of commutator bars. This is obtained by moving coils Nos. 1, 2 and 3, and 67, 68 and 69, up and down until the developed distances from *B* to *K* and from *E* to *L* are such as will bring center of both R_6 on exactly the same line. Then draw the commutator bars 3/4 inch further on and let coils extend 1/4 inch beyond. The distance from coils Nos. 1 to 67 is 66 equal spaces, set off on the armature circumference, each space equal to 1-3 of the distance from center line of one slot to the center line of the next. After the plan view has been finished, the end view is to be completed. Draw in the ends of the coils and give dimensions, except R_3, as shown in diagram. These dimensions are all to be scaled from the drawing and are sufficient for making a former.

* * *

"BEAMS AND PLANES ECCENTRICALLY LOADED."

Editor MACHINERY:

As Mr. Blake, in his letter in the October, 1904, issue of MACHINERY, asks why I assumed the origin of axes at *B* with direction *OB*, also for me to extend my method to a spider having five arms, I offer the following explanation: It is a well-known principle that when a system of parallel forces is in equilibrium, the algebraic sum of their moments about *any* set of rectangular axes in a plane perpendicular to the forces is zero. In other words, the location of the origin and the direction of the axes may be fixed to suit one's fancy. It is consequently correct to assume some convenient point for the origin and through that point draw the axes in a convenient direction. It is a practical convenience to locate the axes so that one force passes through the origin, thus eliminating its moments from the moment equations. Then by drawing the axes through as many of the other forces as possible (generally only one other is possible) more terms may be eliminated from the moment equations. It will be understood then that my reason for selecting the particular point *B* for the origin was because it is correct and convenient, not that it is a better location than any of the other four points, *A*, *C*, *D*, or *O*. Similar reasons determined *OB* as the direction for the *X* axis. It would have served the purpose just as well to have passed the *X* axis through any of the other points, *A*, *C*, or *D*; or the *Y* axis through any of the points, *A*, *C*, *D*, or *O*.

In the light of the foregoing Mr. Blake has a right to and is correct in assuming axes as he has done. Since the location of the axes is immaterial we may take moments of the forces, as I determined them, about the axes Mr. Blake has assumed and we will find that their algebraic sum is, within an allowable per cent of error, equal to zero. The error arises from using the dimensions within the nearest eighth of an inch to the scaled dimensions. If we take moments of the forces, as determined by Mr. Blake, about the same axes we find that their algebraic sum is not zero, consequently the system of forces is not in equilibrium. When a load is supported by a frame of any kind the reactions are so distributed that, when taken with the load, they form a system of forces which is in equilibrium, hence any method of determining reactions which does not give a system of forces in equilibrium is incorrect.

There should be no difficulty in extending the method I gave for a four-armed spider to the case of a five-armed spider. The method, simply stated, is to so proportion the reactions that the resulting system of forces is in equilibrium, as this is a fundamental requirement, and then design the arms in accordance with the assumptions made when proportioning the reactions.

E. E. GRAHAM.

Cleveland, Ohio.

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ANNUAL A. S. M. E. MEETING.

The annual meeting of the American Society of Mechanical Engineers will take place on December 6 at the headquarters of the Society, No. 12 West Thirty-first Street, New York City. The opening session will be on Tuesday evening, December 6, at 9 P. M., when President Ambrose Swasey will deliver the annual address. Following is a list of the papers to be read and discussed at the different sessions:

Wednesday morning, December 7, at the Hall Mendelssohn Union, 113 West Fortieth Street: "A New Hydraulic Experiment," by A. F. Nagle; "A Twist Drill Dynamometer," W. W. Bird and H. P. Fairfield; "Diamond Tools," Gus P. Henning.

Thursday morning, also at Mendelssohn Hall: "Centrifugal Fans," A. J. Bowie, Jr.; "Computation of Values of Water Powers and Damages caused by Diversion of Water used for Power," Charles T. Main; "An Indicating Steam Meter," Charles E. Sargent; "Staybolts, Braces and Flat Surfaces; Rules and Formulas," Robert S. Hale, and "Condensers for Steam Turbines," George I. Rockwood.

Thursday afternoon, Mendelssohn Hall: "Bursting of Four-foot Flywheels," Charles H. Benjamin; "Influence of the Connecting Rod upon Engine Forces," Sanford A. Moss; "Losses in Non-conducting Engines," James B. Stanwood; "Power Plant of Tall Office Buildings," Stirling H. Bunnell; "Pressures and Temperatures in Free Expansion," A. Borsody and R. C. Cairncross.

Friday morning, December 9, at 10 o'clock, at the Society House: "Fuel Consumption of Locomotives," George R. Henderson; "Road Tests of Brooks Passenger Locomotives," E. A. Hitchcock; "Discharge of Water with Steam from Water-tube Boilers," A. Bement; "More Exact Method for Determining the Efficiency of Steam-generating Apparatus," A. Bement; "Forcing Capacity of Fire-tube Boilers," Francis W. Dean.

The list of officers to be voted for, as presented by the Nominating Committee is: For president, John R. Freeman, Providence, R. I.; for treasurer, Wm. H. Wiley, New York; vice-presidents, S. M. Vauclain, Philadelphia; H. H. Westinghouse, Pittsburg, and Fred W. Taylor, Philadelphia; managers, George M. Brill, Chicago; Fred J. Miller, New York, and Richard H. Rice, Lynn, Mass.

STRENGTH OF BEAMS WITH RIBBED SECTIONS —A PARADOX.

WM. N. BARNARD.

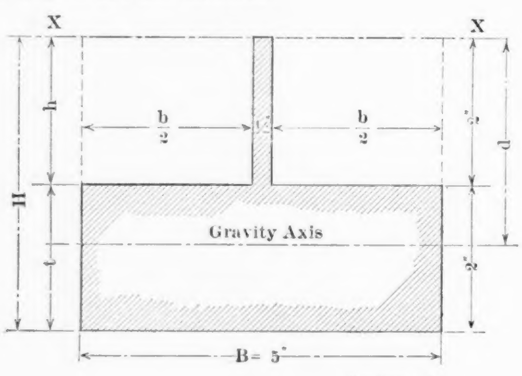
Is it possible for a beam which is broken part way through, to have greater strength than it had originally? Or, what is the same thing, Can a given beam be made stronger by reducing the area of its cross section?

These seem to be absurd questions and probably few people would hesitate to answer in the negative. For the usual cases, that answer would be correct, but it is a curious fact that there can be instances when it would not be.

We naturally, at first, think of the beam with a rectangular section. Any reduction in the area of this section will always decrease the strength of the beam. The same will be true of beams with circular and with polygonal sections, whether solid or hollow. It is also usually true of the ribbed section, such as the T, L and channel, but there may be exceptions. It is generally supposed that the addition of a rib will *always* increase the strength of a beam-member. If added properly the rib *will* be a source of strength, but if added improperly it may be a source of weakness, as we will endeavor to show.

Suppose, for instance, the beam has the section shown in Fig. 1, the rib being quite small and narrow compared with the main body of the section and the material being homogeneous. We would expect the rib to crack under only a slight deflection of the beam. If there was no rib, the beam with the rectangular section (2" x 5") would stand a greater deflection, under a greater load. The beam without the rib would be the stronger of the two.

Since the strength of a beam-member is proportional to the "modulus of its section" the question may be asked: Can the section be such that a reduction in its area will result in a section with a greater modulus?



Machinery, N.Y.

Fig. 1.

We will compare the modulus of the 2 x 5 inch rectangular section, with that of the section shown in Fig. 1.

For the rectangular section the modulus is

$$Z = \tfrac{1}{6}\,B\,t^2 = \tfrac{1}{6} \times 5 \times (2)^2 = 3\tfrac{1}{3}.$$

In which B = breadth of section = 5 inches
t = thickness = 2 inches

To get the modulus of the ribbed section we will proceed as follows, referring to Fig. 1 for the letters and the dimensions used:

The moment of inertia about the axis XX, Fig. 1, is

$$I_x = \tfrac{1}{3}\,B\,H^3 - \tfrac{1}{3}\,b\,h^3.$$
$$= \tfrac{1}{3} \times 5 \times (4)^3 - \tfrac{1}{3} \times (4\tfrac{3}{4}) \times (2)^3 = 94.00.$$

The area of the section is

$$A = BH - bh = (5 \times 4) - (4\tfrac{3}{4} \times 2) = 10\tfrac{1}{2}\ \text{sq. in.}$$

The distance of the gravity axis from the axis XX is

$$d = \tfrac{1}{2}\,(BH^2 - bh^2) \div (BH - bh).$$
$$= \tfrac{1}{2}\,(5 \times 4^2 - 4\tfrac{3}{4} \times 2^2) \div (5 \times 4 - 4\tfrac{3}{4} \times 2) = 2.90.$$

The moment of inertia about the gravity axis is

$$I = I_x - A\,d^2.$$
$$= 94 - (10\tfrac{1}{2} \times 2.9^2) = 5.7.$$

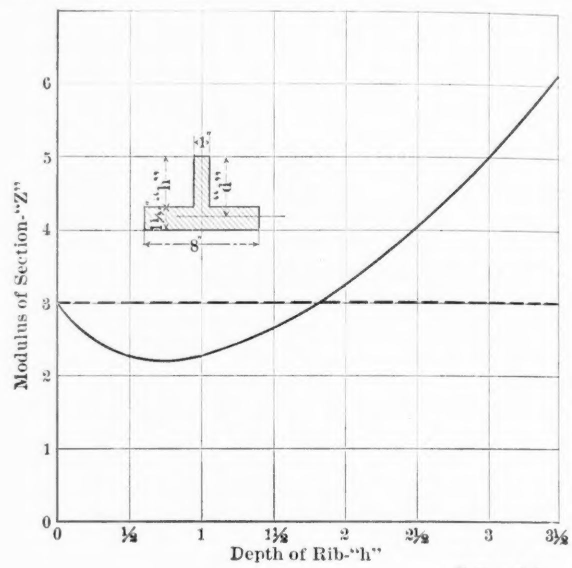
The least modulus of the section is

$$Z = I/d = 5.7/2.9 = 1.96.$$

The ribbed section would therefore be only 1.96/3.33, or less than 6/10, as strong as the section without the rib. A crack through the rib would make the beam 10/6 stronger to resist further fracture.

From the foregoing it appears that there are two breaking strengths for a beam-member with a ribbed section, in which the rib is a source of weakness. At a certain load the rib will begin to crack. This may be called the "*initial*" breaking load. It will take a greater load to cause complete fracture. This may be called the "*final*," or "*ultimate*," breaking load.

In Fig. 2 is given a curve which shows the relation between the modulus of section and the depth of the rib, for the T-section which is shown in the same figure. It will be seen that the modulus of the T-section is less than that of the simple plate, 8 x 1½ inches, unless the 1-inch rib has a greater depth (h) than $1\frac{8}{10}$ inch. The data for the curve are given in the following table:



Machinery, N.Y.

Fig. 2.

h	0	½	1	1½	2	2½	3	3½
I	2.25	2.75	3.77	5.52	8.16	11.78	16.65	22.75
d	.75	1.21	1.65	2.08	2.50	2.90	3.30	3.68
Z	3.00	2.27	2.29	2.65	3.26	4.06	5.05	6.17

In the foregoing we have spoken only of the strength of a beam as affected by the rib. There is also the consideration of the *stiffness*. This will always be increased by the addition of a rib. The stiffness is proportional to the moment of inertia of the section, which will always be made greater by increasing the area of the section in any way.

* * *

The trial electric locomotive built by the American Locomotive Co. in conjunction with the General Electric Co. of Schenectady, N. Y., has been tried on a trial track near Schenectady, and the results seem to indicate that the New York Central's terminal problem, so far as a motor is concerned, is solved. For years the New York Central and New York, New Haven and Hartford Railway has labored under great difficulties in handling the traffic at the New York terminal. The smoke and gases which accumulate in the Park Avenue tunnel make this section highly disagreeable to passengers and a menace to their safety, for there are periods when practically no other system of signals can be depended on but torpedoes. The terminal improvement plans require the use of electric motors and exclude the steam locomotive entirely in the New York City terminal proper. The specifications require electric locomotives capable of hauling trains weighing 435 tons, to make a run of 34 miles (Grand Central Station to Croton) in 44 minutes without stopping, and with only one hour lay over to be able to keep up this service continuously. The trials of the first locomotive built seem to indicate that its speed and acceleration are such as to easily accomplish the trip in the required time. With a 500-ton train, an acceleration of six-tenths of a mile per minute can be acquired from a dead stop, which means that one minute after the power is applied the train will be running at the rate of nearly 30 miles per hour. The trial track at Schenectady is only four miles long, so that it was not possible to make prolonged tests of speed acceleration, but speeds of 60 to 75 miles per hour were made while hauling a 500-ton train.

IMPROVEMENT ALL ALONG THE LINE.

THE MOST COMPREHENSIVE REPORT OF THE MACHINERY TRADE EVER PUBLISHED.

The machinery trade is unanimous in the opinion that business prospects are good for 1905, and that the improvement has already set in. To help manufacturers in forecasting the immediate future of the machinery trade a letter containing the following questions was sent to several hundred firms:

1. Has there been any improvement in your business lately?

2. Have we reached the bottom of the present business depression; if not, do you anticipate an early improvement in general business conditions?

3. What are the business prospects for 1905 in your line?

The substance of the replies received is given below in condensed form and almost without exception they express the belief in an upward trend in business conditions:

Acme Machinery Co.: Some improvement within 30 days, indications are for early improvement in business conditions. Inquiries are much more numerous than for some time past. Prospects encouraging.

Ajax Mfg. Co.: Quite a little improvement lately, and business prospects seem very bright for 1905.

Akron Electrical Mfg. Co.: Radical change during the past six weeks. Booked more orders than previous four months combined. Have orders enough to keep factory running at fullest capacity for at least four months.

Albro-Clem Elevator Co.: Business improved wonderfully last two or three months; been very busy for that period. Think business prospects 1905 very bright.

T. R. Almond: Decided improvement in business latter part of September and October, which is continuing. Present volume of business equals that of same time one year ago. Have unquestionably passed the low point, and prospects for 1905 ought to be as good as any year that manufacturing industries of this kind have seen.

American Ball Co.: Have had all the business in balls and ball bearings during past year that we could handle; sufficient orders on hand to keep us busy for the next two months or more. Outlook for 1905 very encouraging.

American Gas Furnace Co.: The business of this company has suffered no depression whatever. Facilities for turning out work have not increased as rapidly as demands for our product. Are therefore hardly in position to throw light upon the question. Overloaded with orders.

American Mche. & Mfg. Co.: The present with us is not so busy as short time ago. Large amount of work in sight and we think we have reached the bottom and that from now on the tendency will be upward.

American Roller Bearing Co.: Business exceedingly slack past summer and fall, but since election have noticed a remarkable change; have closed a number of deals, and prospects excellent.

American Tap & Die Co.: Our business has doubled during the past year. Have not noted any particular depression, possibly owing to increased energies made to secure larger business, which we have done. Anticipate a good business for 1905.

American Tool & Mche. Co.: There has been practically no improvement in our business lately. Think we have reached the bottom of present business depression and anticipate early improvement in business conditions. Prospects for 1905 in our line we think are very good.

American Tool Works Co.: Business within last three months shown remarkable improvement. Are putting on additional men almost daily; also some additional equipment. Our opinion healthy and continued improvement has set in; anticipate enough business in 1905 to keep plant fully employed.

American Watch Tool Co.: Our business gradually improving from year to year, and this year has been no exception. We have felt no business depression. Employed our usual complement of machinists all through the season, and our business compared favorably with that of 1903. No reason to expect anything less for 1905, but look for the same steady, conservative improvement.

Arguto Oilless Bearing Co.: Business materially increased of late; not only due to healthier condition of trade in general, but also from effective advertising in Machinery. As "Arguto" is used in various industries we judge from increased orders and number of inquiries that business depression is now a thing of the past. Our prospects for 1905 are very bright.

Atlas Mche. Co.: Marked improvement in our business lately. Our foreign trade growing larger as well as our home trade. Can only conjecture as to whether we have reached bottom of present depression but confident that now the election is over every one can devote his time to business instead of to politics. Prospects much better for 1905 than for the present year.

Auburn Ball Bearing Co.: The last month have had marked increase in our inquiries, and think next two months business will pick up very materially. Unable to fathom depression in metal trades which has continued since August, 1903, but from increased number of inquiries think that in next two or three months business in the metal trades will have big improvement.

Automatic Mche. Co.: Have three distinct lines of business, i. e., marine work; original automatic wire-forming and experimental machinery, and automatic threading lathes. Marine trade has been good and is rapidly increasing; special work is and has been constant for past year; automatic threading lathe output depends upon the machine-tool trade, and this is steadily increasing. We notice foreign demand leads domestic, but home inquiries are more brisk and we confidently look for a uniform advance all along the three lines. We certainly believe we are at the ebb of the business depression.

Henry Carey Baird & Co.: We think decidedly we have reached bottom of depression; we believe prospects are very good.

Baird Mchy. Co.: Business has improved quite a little in past thirty days; inquiries very encouraging, and point, we think, to a lively business in the near future. Feel that late business depression was buried on Nov. 8th.

Baker Bros.: Our machine tool business very quiet for last three months, but think there has been improvement since first of month, and from present outlook are expecting good trade after first of year, believing that business conditions fully warrant such a hope.

Bantam Mfg. Co.: Improvement in business; prospect for coming year: our old time boom. The bottom was reached last August.

Edwin E. Bartlett: 1. Yes, decidedly. 2. We do. 3. Good.

Wm. Barker & Co.: Great improvement; expect to have a great deal more to do shortly; prospects for 1905 very favorable.

Bay State Stamping Co.: Our business gradually improving since last January, and if there has been a depression in other lines it has not affected us in any way. Business prospects for 1905 seem to be very bright.

The Bay State Tap & Die Co.: Past two months decided improvement in our business.

Bayldon Mche. & Tool Co.: There has been no increase in sales in our business lately, but inquiries vastly increased within last two weeks. Believe bottom of business depression was reached during the early summer months, and look for steady improvement.

H. G. Barr: Seems to be an improvement. Sales are on the increase. Think that machine tool business has reached bottom of present depression and that heavier tools will advance more noticeably than light tools for a little time. Expect twice the business for 1905 than in 1904.

Bausch Mche. Tool Co.: 1. There has been an improvement in our business lately; 2, yes; 3, we would give a good box of cigars to know.

Beaman & Smith Co.: Think indications are favorable for an improvement; think business prospects are better than they were a year ago.

Beaudry & Co.: Marked improvement in orders and tone of inquiries. bottom of depression we consider well past, and look for steady improvement in business conditions. Prospects for 1905 most promising.

Becker-Brainard Milling Mche. Co.: Quite a little improvement in conditions last two months. Believe bottom has been reached; are anticipating early improvement; do not look for much before new year. Believe prospects for 1905 good in machine tool business.

Belden Mche. Co.: Improvement of late, and we feel very optimistic concerning outlook for coming year.

David Bell Eng'g Works.: Decided improvement in orders; believe that the prospects for next year are fairly bright, although we do not look for a banner year until 1906.

Benskin Mfg. Co.: Improvement in our business recently; certainly have reached bottom of present business depression. We have entire confidence in an early improvement in general business conditions, and the prospects for 1905 as they appear to us, are all that could be desired.

Bertsch & Co.: Since election business steadily increased. Believe worst of business depression passed, and outlook for 1905 very good.

Charles H. Besly & Co.: Marked improvement in our business lately. Our customers seem to be starting on a period of increasing activity. Business prospects for 1905 are good.

Bethlehem Fdy. & Mche. Co.: Our business has shown decided improvement lately, and believe depression is rapidly passing to buoyancy. Every indication of improvement in general business, and prospects for 1905 very encouraging.

H. Bickford & Co.: Outlook for better conditions in 1905 is excellent.

Bickford Drill & Tool Co.: Improvement last six weeks; believe will continue, although do not anticipate marked increase until after first of year. Foreign trade also improving and 1905 should develop into a good year for us.

Bignall & Keeler Mfg. Co.: Inquiries strong and their general tone gives the impression that people intend to buy in the near future. Think there is already an improvement in business conditions.

Hugo Bilgram: My opinion is that recovery will be slow, as usual after depressions.

Billings & Spencer Co.: Believe we have reached bottom and indications are we are going to experience improvement in business from now on. Prospects very encouraging; increased inquiries for products in our line.

Binsse Mche. Co.: Marked improvement in our business since September. Bottom of depression passed, look for not merely an early improvement, but for a demand for prompt delivery which will disappoint a great many. Foreign trade shows improvement.

Borden Co.: 1, considerable improvement lately; 2, we do; 3, the best.

Boynton & Plummer: Look for early improvement and steady increase. Look forward to 1905 as a good business year in our line.

Bradford Mche. Tool Co.: Decided improvement in our business lately; now operating our shops over-time. Foreign business good; trade at home improving every day. Prospects for next year very bright.

R. H. Brown & Co.: Decided improvement in our business in last six weeks or two months. Think have reached bottom of depression and anticipate fair business this winter, with improved conditions after middle of January.

Brown & Sharpe Mfg. Co.: Autumn business has shown improvement over somewhat quiet tone of summer months. Probably conditions will continue to improve in future. Prospects for 1905 in our line are favorable.

Brown Hoisting Mchy. Co.: 1. Slight. 2 and 3. Look for big improvement immediately.

Brown & Zortman Mchy. Co.: Slight improvement in last thirty days. Closed up some business that has been hanging fire for six or eight months, and this business is from some of largest corporations, indicating that the big people are once more going into the market. We feel bottom has been reached and are once more starting to

recover from general depression felt more in Pittsburg territory than in any other part of country.

BUILDERS' IRON FOUNDRY: Slight improvement in our grinding and polishing machinery line. Orders larger and more frequent; more inquiries. Looking for early improvement, possibly not until first of year, but believe in 1905 there will be a decided improvement along all lines of manufacture.

BUTTERFIELD & CO.: Business improved very much since middle of year; believe bottom has been reached; prospects for 1905 are excellent.

ROYAL E. BURNHAM: Business was very good up to the first of September, when there was a marked falling off. Since settlement of political conditions, there are signs that business will return to its normal conditions.

JOHN T. BURR & SONS: Outlook for immediate future of our business very bright indeed. Our business for ten months this year more than equaled sales for whole of last year; numerous inquiries covering everything we manufacture.

BUTLER CHUCK CO.: Improvement in chuck demand recently and an undercurrent of inquiry which indicates that tide has already turned; strong grounds for expecting that future will not withhold its harvest from those who diligently plant.

CARBORUNDUM CO.: Some improvement in business lately, and from general outlook in this locality, look for steady improvement from now on.

CARPENTER TAP & DIE CO.: Fall trade shows great improvement, and indicates a good year for 1905.

CARR BROS.: Our business has shown steady improvement the last four months, with good prospects for the future.

CARTER & HAKES MCHE. CO.: Business very even and steady during the whole of last year, and recently no marked change. Prospects of plenty of work for the next year.

CHAMBERSBURG ENG'G CO.: Decided improvement in our line of business lately.

CHANDLER PLANER CO.: Large amount of business in sight, but that may be due to the fact that we are offering something out of the usual course of machine tools. We are, however, in the market as purchasers, and the fact that business is reviving is evident from increased difficulty in getting promise of deliveries of certain tools that a few months ago were seeking purchasers.

CHATTANOOGA MCHY. CO.: 1. Yes. 2. We do. 3. Last six months our business improved materially; look for next year to be most prosperous we have had.

CINCINNATI MACHINE TOOL CO.: Much better feeling in machine tool market; some orders placed which have been hanging fire very long. Anticipate early improvement. Indications for next year are for good business.

CINCINNATI PLANER CO.: Considerable improvement during past sixty days. Believe are now starting on period of good healthy business. Anticipate increase of fully 50 per cent. for 1905. Believe people are gradually having their confidence restored.

CINCINNATI PUNCH & SHEAR CO.: Business was unusually quiet until about Oct. 1st, since which time decided improvement, not only in inquiries but in substantial orders. We are quoting as many probably now as during the last few rush years. Believe will be busy the rest of this year and busier next.

CINCINNATI SHAPER CO.: Very decided improvement in business conditions lately. No doubt bottom of the present business depression has been reached, and we anticipate the year 1905 to be a banner one.

JAS. CLARK, JR., & CO.: Marked improvement in our manufacturing business of late; in fact, we have as much as we can possibly do for several months to come with our present capacity. Believe business will gradually improve until in the very near future we believe that business will be on a boom.

CLEVELAND ATOMATIC MCHE. CO.: Last four months our business has been extremely good. Operating factory to fullest capacity, and hardly able to keep up with orders. Hardly think we have at the present time a business depression. True, in a number of branches, we are not as busy as one year ago, but nevertheless general business of country is in fairly good condition. Prospects in this country at present time exceedingly bright, and believe that after holidays business will improve rapidly.

CLEVELAND CAP SCREW CO.: Material improvement in trade last two or three months; look for a continuance, or even further improvement of this condition.

CLEVELAND CRANE & CAR CO.: Business has improved materially; that for last three months much better than for eight months preceding. Believe bottom has been reached. Do not, however, anticipate much improvement until early next spring, after which we believe business will be as good as ever.

CLEVELAND PNEUMATIC TOOL CO.: Do not anticipate much revival until April, 1905; believe things will then get into pretty good swing and go along for several years in elegant shape.

CLEVELAND TWIST DRILL CO.: Business during past year considerably less than during three previous years; some improvement during the past sixty days. Think bottom reached, and every prospect for fine business for 1905.

CLING-SURFACE CO.: Business steadily improving during all fall months. Believe will continue to improve and indications point to prosperous year during 1905.

R. M. CLOUGH: See little change as yet. Expect better times.

COLUMBUS MCHE. CO.: Look for no great improvement until after first of year. Business very fair past few months and we expect it to continue; with spring there will be real good buying and everything will move along in good healthy way.

CROWE METAL MFG. CO.: Our business a new one, and growing steadily. Pick-up lately indicates we are on up grade again.

CURTIN-HEBERT MFG. CO.: Slight improvement in our business of late.

CURTIS & CURTIS CO.: Improvement since last June. While still behind the booming times of two years ago, certainly improving, and we look for several years of good business to come.

CURTIS & CO. MFG. CO.: Do not anticipate further decline in business, but a somewhat increased demand for our products.

CUSHMAN CHUCK CO.: Great increase of activity among our own customers and for many weeks inquiries and orders have been coming in more freely than for several months; indicates an improvement in the machinery trade generally and also a busy season for us.

W. P. DAVIS MCHE. CO.: Improvement in business within last two months. Believe prospect for business in 1905 good. In manufacturing of machine tools there will not be the demand from the dealers we have had in the past, as we believe their policy will be to buy only for their present requirements, as nearly all have been carrying very heavy stocks. Believe general demand all over the country will be good.

DERRY-COLLARD CO.: Improvement in our business during the past month. We feel there is upward tendency in business; anticipate a good trade during coming months; prospects for 1905 better than for past two years.

DESMOND-STEPHAN MFG. CO.: Are new in the business but business satisfactory and constantly increasing.

DETROIT TWIST DRILL CO.: Improvement. Certainly all the conditions are now favorable.

DIAMOND SAW & STAMPING WORKS: Output for September largest in history of our business. Believe we can look forward to a steady and marked improvement, and that next four years will show no decrease in the volume of trade as compared with the past term of prosperity.

DODGE & DAY: Our Mr. Day, returned from extensive trip through west, reports indications are there will be very material improvement in business shortly.

DRAPER MCHE. CO.: Marked improvement in business during last month; bottom of depression reached; from now on business will steadily become better. From orders placed and inquiries received, we anticipate a good business in 1905.

DRESES MCHE. TOOL CO.: Since October, business improved considerably; outlook very good; think the prospects for 1905 very promising.

EASTERN MCHY. CO.: Business shows improvement past two months. Has been good past three or four years.

EATON, COLE & BURNHAM CO.: Considerable improvement of late; good prospect both for this year and for 1905.

ELWELL-PARKER ELECTRIC CO.: Distinct improvement lately; do not hesitate to say we have considerably passed bottom of depression. As to 1905, are sure it will be a first-class year for every one.

ERIE ENGINE WORKS: Improvement in business conditions of late; anticipating further and early improvements in general business, and hope it will be realized.

ERIE FDY. CO.: Very decided improvement in our business; very hopeful for a good year in 1905.

EXCELSIOR TOOL & MCHE. CO.: Business brightened up lately; feel encouraged to believe business will constantly improve, and that prospects for 1905 are bright.

FANEUIL WATCH TOOL CO.: Did not feel recent depression very much; looks as though we are going to have an extra big year.

FAY & SCOTT: Our business very good up to last July; since, rather quiet; our prospects are bright for 1905.

FENN SADLER MCHE. CO.: Business improved steadily. Prospects for 1905 look very bright to us.

FERRACUTE MCHE CO.: Business prospects for coming year seem good. Have had all the work we could do during the past year. Judging by number of orders we expect to have enough to do in our new fire-proof works.

FITCHBURG MCHE. WORKS: Look forward to good business for ensuing year.

FLATHER & CO., INC.: Decided improvement; busy as can be; large number orders on hand and are receiving more inquiries.

MARK FLATHER PLANER CO.: Have been able to close a few very nice orders at excellent prices. It would appear that business will begin to come in shortly after the opening of new year, probably about February or March; from that time on we anticipate as much or more business than able to take care of for next three or four years.

FOOS GAS ENGINE CO.: For the last six months have had more business than could handle, with every indication of its continuing.

FOOTE, BURT & CO.: Business seems to have opened up in better shape than during October. All signs that we will very speedily have a resumption of good business. Think prospects for 1905 extremely good in our own line and in all machine tool lines.

FOSDICK MCHE. TOOL CO.: Business improved much since first October; now running full time and look forward to good year. Believe there will be fair and steady demand for machine tools.

FOX MCHE. CO.: Inquiries and orders coming in much better; prospects for good fall and winter business very bright.

WILLIAM E. GANG CO.: 1. Yes. 2. Yes. 3. Prospects for 1905 in our line, good.

WM. GANSCHOW: From large number of inquiries both from local concerns and also out of town, business must be commencing to pick up again. No reason on earth why business in 1905 should not be a good deal better than the last year.

WM. GARDAM & SON: Business very even during past year; from number of inquiries prosperous year for 1905 certainly indicated.

GENERAL PNEUMATIC TOOL CO.: Last two and a half months marked increase in amount of business; confident that there will be a steady improvement.

GEOMETRIC DRILL CO.: Marked improvement past few weeks both in inquiries and orders; feel very much encouraged; prospects for 1905 in our line very bright indeed.

GOODELL-PRATT CO.: Believe outlook as regards small tool trade very encouraging; believe—and not without having carefully considered the situation—that 1905 will be biggest year small-tool manufacturers ever enjoyed. Understand us, we do not presume to comment upon conditions existing in the machinery line, for that is foreign to our business.

GIANT MOTOR CO.: Business good for last two months, with best prospects for 1905.

GLASGOW IRON CO.: Think business prospects for 1905 are very good.

GLOBE MCHE. & STAMPING CO.: Sales for 1903 50 per cent. higher than in 1902, and for 1904, fiscal year ending October 1st, 33 1-3 per cent. higher than for the previous year. Now have sufficient business to run six or eight months. Prospect for prosperous year 1905 bright.

GODDARD MCHE. CO.: Business improved somewhat last few weeks. Believe situation will continue to improve; look for much better business in 1905.

GOULD & EBERHARDT: Quite some business right along, anticipate gradual improvement with good steady demand during the coming year.

GRAY & PRIOR MCHE CO.: Glad to say have not felt depression; prospects in our lines for coming year excellent.

GREAVES, KLUSMAN & CO.: Decided improvement in business lately; prospects for 1905 very good.

GUARANTEE ELECTRIC CO.: Surprising increase in business since election; think that for the next year or two it will be steadily on the increase.

HAMILTON MCHE. TOOL CO.: 1. Yes. 2. Under impression we have seen worst of present business conditions. 3. Everything indicates we will have an average year.

HAMMACHER, SCHLEMMER & CO.: 1. Yes—barring slight set-back due to our moving. Believe there will be a healthy, conservative period for some time to come.

HARRISON SAFETY BOILER WORKS: Past sixty days business conditions steady improvement; anticipate full resumption in practically all lines by commencement of new year.

HAYES FILE CO.: 1. Yes. 2. We think we have. 3. We think the outlook very bright.

HAZELTON & DONALD MCHE. CO.: Are of opinion tendency will be to go a little slow for a while, but prospects for 1905 exceedingly favorable.

HEALD MCHE. CO.: Very busy, indeed, ever since we moved our plant to Worcester. Believe that last five or six weeks decided improvement in inquiries, and orders that will be even more pronounced after the first of the year.

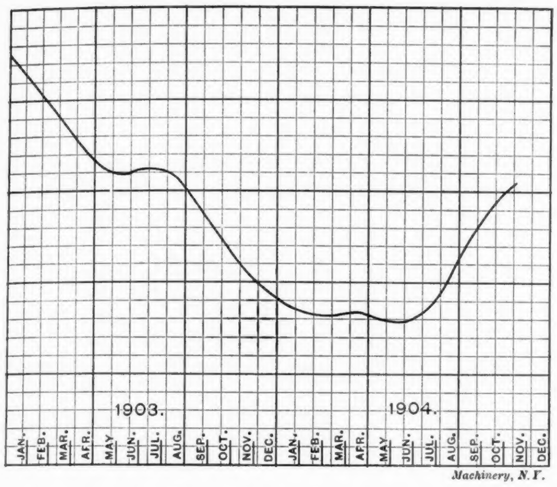
HENDEY MCHE. CO.: Substantial increase past two or three months; have a large number of unfilled orders. Anticipate very good business coming year.

HESS-BRIGHT MFG. CO.: Our business continually improving. Prospects for 1905 very satisfactory.

GEORGE WILLIAM HOFFMAN: Business lately very good until last week or so; depression, I presume, due to election; expect my sales for 1905 to almost double those of previous years.

HILL, CLARKE & CO., Boston, Mass.: Anticipate a fair amount of business during greater part of next year.

HILL, CLARKE & CO., Chicago, Ill.: Your question can be very nicely answered by little curve inclosed herewith; shows that business dropped off about January, 1903, reached its lowest notch in May and June, and



Machinery, N.Y.

since then has been considerably on increase, and according to outlook ought to be back to normal condition by next spring. What we mean by "normal" would be a condition to compare very close to year 1902.

HISEY-WOLF MCHE. CO.: Think prospects for 1905 are first-class in all lines; look for good healthy business, from January 1st particularly.

HOGGSON & PETTIS MFG. CO.: Business about the same past month or so; look for increase soon, with prospects good for 1905.

B. P. HORTON: Very quiet, but looking forward to steady increase. See no reason why 1905 should not be a record breaker.

E. HORTON & SON CO.: Some improvement of late; anticipating a still further improvement in the near future. Prospects for 1905 good.

E. F. HOUGHTON & CO.: 1. Yes. 2. Running to full capacity. 3. Elegant.

HOWARD IRON WORKS: Have noticed improvement in our business lately. Prospects for 1905 good.

HURWOOD MFG. CO., INC.: Prospects for doing a good business in 1905 rather better than fair.

HYATT ROLLER BEARING CO.: Have noted a general improvement in the machinery lines past four or five months. From indications are going to have increased business in all lines for at least two years to come. Prospects for 1905 are particularly bright in our line.

IDEAL MFG. CO.: Improvement in situation during last two months; inclined to think will be an improvement in business conditions early in 1905.

INTERNATIONAL CORRESPONDENCE SCHOOLS: Our business has annually shown large increase since origin, in 1891. Believe that coming year will be best the Schools ever experienced.

INTERNATIONAL POWER VEHICLE CO.: Improvement very perceptible in our case.

INTERNATIONAL SPECIALTY CO.: Business only started about six months ago; fair demand for our emery wheel dresser; anticipate a good business next year.

IVES MFG. CORPORATION: 1. Yes. 2. Passed bottom of depression. 3. Prospects for 1905 of the brightest.

JACOBSON MCHE. MFG. CO.: Business shows marked advance each week. Think business will be at least up to normal standard in short time if not considerably above.

D. O. JAMES: From present indications future outlook very cheerful.

R. A. KELLY CO.: Look for better trade during 1905 than we have enjoyed for some time past.

KEMPSMITH MFG. CO.: Business in our line picking up nicely; feel that depression has reached its bottom, at least we hope so.

KENDRICK & DAVIS: 1. Fully equal to last year. 2. Yes. 3. Very good.

KEYSTONE DROP FORGE WORKS: Improvement lately; tone, in general, seems to indicate continued improvement. Prospects for 1905 encouraging.

KILBOURNE & JACOBS MFG. CO.: Very decided improvement during the last two months. Prospects for 1905 excellent.

KING MCHE. TOOL CO.: Number of inquiries increasing; think there will be a temporary boom in our line caused by placing of orders by such concerns as have held off until last minute; anticipate good average year in 1905.

LANCASTER PEERLESS EMERY WHEEL CO.: Feel much encouraged; have had several very nice orders since election.

MAIN BELTING CO.: We are right busy; think prospects upward and first-class.

EDW. LINDMUELLER: Decided improvement lately; think have reached low ebb of business depression, and are on the rise. For 1905 prospects very encouraging; anticipate busy season.

LINK-BELT ENGINEERING CO.: Orders since the 8th noticeably more numerous than during period immediately preceding that date. Look for material improvement in business conditions and a general rising tide.

LODGE & SHIPLEY MCHE. TOOL CO.: Improvement in orders in last 60 to 90 days. Business prospects for the future very bright.

LUCAS MACHINE TOOL CO.: 1. Evidences of substantial improvement. 2. Think we are well on the road to better conditions. 3. Favorable.

WALTER MACLEOD & CO.: Have every confidence that coming year will show great improvement over the present one. Our business better last six months than six months previous. Railroads and other large users buying more generously; look for even better returns in early future.

F. B. MCCROSKY MFG. CO.: Decided improvement in demand for our product, beginning early part of October. Believe bottom of present depression was reached some time ago. Prospect for 1905 excellent.

MCDOWELL, STOCKER & CO.: Inquiry getting some better. Believe there will be early improvement in general business conditions, but not much before first of coming year.

MANNING, MAXWELL & MOORE: Marked improvement in the machinery business this month. Believe have reached bottom present business depression; anticipate good general business, without marked increase in prices until demand is considerably larger, when we think prices will advance. That, of course, will rest largely with the manufacturers, and is a matter they will control, according to amount of business they have in proportion to their capacity. Think prospects in our line for 1905 very good, though do not look for any great boom.

MANVILLE BROS. CO.: Great improvement recently, and think our sales will be very much increased during coming months.

MAYER & CO.: Tendency of improvement; more inquiries coming in. As for 1905, think it will be beginning of era of prosperity and good feeling.

MEISEL PRESS & MFG. CO.: 1. Yes. 2. Yes. 3. Very good.

OTT. MERGENTHALER & CO.: Some improvement, and we anticipate more.

MERRELL MFG. CO.: Business not improved any as yet, but anticipate general improvement in conditions. Prospects for 1905 very bright in our line.

MERRILL BROS.: More inquiries for machinery within last month than for six months previous. Our business not depressed but anticipate general improvement.

MERRITT & CO.: Decided improvement in past sixty days; business has steadily grown during past three or four years.

MICHIGAN LUBRICATOR CO.: Decided improvement in trade conditions; anticipate a boom year in 1905.

AUGUST MIETZ: Some improvement in our business lately; expect early improvement in conditions. Prospects for 1905 in our line very good.

MILLER'S FALLS CO.: Very perceptible improvement commencing about October 1st. Conditions favorable for continued increase in volume of business.

MILWAUKEE TOOL CO.: Outlook for 1905 not discouraging for beginning of year; the latter part will be a commendable season, comparatively speaking.

MITTS & MERRILL: Considerable improvement during past month; business for two or three preceding months comparatively light. Look for steady improvement in our business during next year.

MINER & PECK MFG. CO.: Orders now coming in fairly well; quite an increase in inquiries.

MONTGOMERY CO.: Considerable improvement during last two months. Believe winter trade is going to be fairly good, and by spring conditions will be excellent.

MORSE CHAIN CO.: Our orders for drives for machine tools less than usual, but for chain power transmission increasing very rapidly, and have been during last three months.

C. A. MOSSO: My business increased more than double in last year. Am not looking for a boom, but good steady business, with healthy increase for some time to come. Prospects for 1905 were never better.

FRANK MOSSBERG CO.: Steady increase in our business during October; prospects at present writing for 1905 better, and we look for a good business.

MUELLER MCHE. TOOL CO.: Have of late noticed improvement in machinery business. Prospects for 1905 in our line very good.

NATIONAL MCHE. CO.: Have had good year. Outlook very good for 1905.

NATIONAL SEPARATOR & MCHE. CO.: Very good business; looking for amount of business for 1905.

NEW ERA MFG. CO.: The present year, as a whole, will be one of the best in the history of our company, and prospects for 1905 very flattering in our line.

NEW ENGLAND ROLLER GRATE CO.: Prospects for coming year very bright. Our business on steam specialties very good throughout the year.

NEWTON MACHINE TOOL WKS.: Steady increase in our business last two or three months, especially within the last week or so. Do not anticipate any boom; we think by first of year there will be a good steady business, especially so with railroad companies.

NILES-BEMENT-POND CO.: Business with us very much improved; prospects for coming year we consider most promising.

NORTHERN ELECTRICAL MFG. CO.: Marked improvement in inquiries and orders since September. Business at the present time is very satisfactory. The prospects for 1905 seem good.

NORTHERN ENG'G WORKS: Quite an improvement both in inquiries and orders placed. Anticipate further improvement in business next three or four months.

NORTHWESTERN MFG. CO.: Business steadily improved for last three months. Believe bottom of depression was reached two or three months ago and the prospects for next year are remarkably good; demand on the increase all the while for high grade apparatus such as we make.

NORTON EMERY WHEEL CO.: Business very good right along. Prospects splendid.

OHIO MCHE. TOOL CO.: Some improvement recently, and look for it to continue. Are looking for a much better business in 1905.

L. H. OLMSTED: Decided improvement in demand for goods during past six weeks; continues at present.

OLIVER MCHY. CO.: Material improvement last three or four months. Large number inquiries, which will undoubtedly lead to future business. Anticipate 1905 being a record breaker.

ONEIDA STEEL PULLEY CO.: Been making all we could and unable to fill our orders. Have not realized there was any depression.

J. L. OSGOOD: Find business in machinery line in this section improved since August, inquiries increasing and orders coming in for machinery. Indications are 1905 will prove a prosperous year to the machinery trade.

CHARLES PARKER CO.: Certainly a decided improvement in business last six weeks or two months. Reached the bottom on business depression. Prospects for 1905 in our line of goods is bright.

W. M. PATTISON MCHY. CO.: Cannot find great improvement in business, although last month showed a little. Better prospects for 1905, though we do not consider there will be any rush in the machine tool line.

PEDRICK-SMITH CO.: Look forward to prosperous year. Mail very encouraging, containing many inquiries; very busy; have started night shift, to get out the orders.

PERKINS MCHE. CO.: Improvement of late, starting about 45 days ago; business on the increase; obliged last week to run night and day to keep up with orders.

PERRY TIME STAMP CO.: 1. Yes. 2. Believe have reached bottom of present business depression. 3. Business prospects for 1905 in our line excellent.

PHILADELPHIA PNEUMATIC TOOL CO.: Sales for October far exceeded those of preceding month. Inquiries good, coming from all portions of country. Anticipate a very prosperous year for 1905.

PHILLIPS PRESSED STEEL PULLEY WORKS: Too new to have experienced business depression; we hear confidence expressed everywhere.

PHOENIX MFG. CO.: More calls at present; think tide has turned, and good business will be with us.

PHOSPHOR-BRONZE SMELTING CO., LTD.: Business shows slight improvement of late.

PIKE MFG. CO.: Confident business will pick up, and are anticipating large demand for our goods for the next six months.

L. W. POND MCHE. & FDY. CO.: Improvement; numerous inquiries; feel prospects for 1905 in our line very bright.

POTTER & JOHNSTON MCHE. CO.: Past six or eight weeks domestic demand greatly increased; foreign sales equally satisfactory; present outlook for 1905 points to a banner year.

POWER & SPEED CONTROLLER CO.: Considerable improvement past two months and bottom of the business depression reached; upward tendency. Prospects for 1905 would seem good if present advance continues.

PRATT & WHITNEY CO.: No serious depression in our business during 1904.

PRENTICE BROS. CO.: Business improved greatly within last three or four weeks.

GEO. G. PRENTICE & CO.: Consider that bottom of depression reached. Prospects very bright for 1905.

PRENTISS TOOL & SUPPLY CO.: Our business has shown steady improvement since August 15th. Expect satisfactory business for 1905.

QUEEN CITY MCHE. TOOL CO.: Improvement in business conditions; the machine tool line has taken quite a jump in this vicinity. Look for era of good times.

A. D. QUINT: Decided improvement in business, foreign and domestic, in past six weeks. Spring of 1905 will see everything on the boom once more.

RAILWAY APPLIANCES CO.: Marked improvement in our machinery business of late; feel tide has already turned. Prospects for 1905 show promise more business than any time for last eighteen months.

RAND DRILL CO.: Prospects for business for 1905 good.

RANSOM MFG. CO.: Expect, from now on, business will be better; look for a banner year in 1905.

FRANCIS REED CO.: Indications seem to be good in my line for 1905.

RIDGWAY MCHE. TOOL CO.: Notice improvement; have booked sufficient orders within last week to give us work for nearly a year.

ROBERTSON MFG. CO., INC.: Past month marked improvement; prospects for 1905 very good. Trade on our rapid cut saws especially bright.

ROBBINS & MYERS CO.: Substantial improvement last few weeks over business a number of months preceding. Indications point to a very favorable year.

JOHN M. ROGERS BOAT, GAUGE & DRILL WORKS: Decided improvement in the general business conditions.

ROTH BROS. & CO.: Prospects in our line look very bright.

ROWBOTTOM MCHE. CO., INC.: Had fair business right along; have every confidence 1905 bringing complete revival of good business.

ROYERSFORD FDY. & MCHE. CO.: Quite an improvement in our business within last two months. Anticipate a very general improvement in conditions. Our prospects for 1905 exceedingly bright.

RUGGLES-COLES ENG'G CO.: Very decided improvement last month. Look forward to large business the coming year.

SAGINAW MFG. CO.: Considerable improvement in our business of late; prospects for 1905 excellent.

SAWYER TOOL MFG. CO.: Present business very good; outlook for future bright.

SCREW CUTTING CO. OF AMERICA: Believe we shall have all we can do in 1905.

SCHELLENBACH & RADCLIFFE: We have all we can possibly get out with our capacity until January, 1905. Our prospects for next year very good indeed.

SCOTT & SONS: 1. Yes. 2. We have. 3. Good.

SEBASTIAN LATHE CO.: Believe we are entering on another era of prosperity. Fully expecting a good demand for our tools for the coming year.

SKINNER CHUCK CO.: 1. Yes. 2. Yes. 3. Very good.

SLOAN & CHACE MFG. CO.: Very decided improvement lately; expect business will at least equal 1903 and will probably be much better.

J. T. SLOCOMB CO.: Expect satisfactory business during coming year.

ERNST G. SMITH: Had an average amount of business, and feel confident business will greatly increase in 1905.

J. D. SMITH FDY. SUPPLY CO.: Our business increased about 20 per cent. past two months; if present growth continues, will not be long before we are doing as much as we did last year.

J. E. SNYDER: Business past few months rather quiet. Getting some foreign orders, but domestic trade slow. Will see a good fair business during 1905.

SPEED CHANGING PULLEY CO.: 1. Yes, 50 per cent. 2. Yes. 3. Splendid.

SPRAGUE ELECTRIC CO.: Recent improvements; prospects 1905 in our line are exceedingly good.

SPRINGFIELD MCHE. TOOL CO.: Considerable improvement in our business commencing September first. Believe that a steady improvement in general business conditions has now set in. For 1905 a fair business to be expected.

STANDARD ENG'G CO.: Better inquiry noted in our line; sufficient amount of machine orders on hand to keep us busy for at least three months. Believe general conditions are on the mend.

STANDARD ROLLER BEARING CO.: Considerable increase in our orders lately; appears to us business for 1905 will be very heavy. Busy all the time; have just doubled size of our plant.

STANDARD WELDING CO.: Business in this city has been good throughout; have full confidence in immediate future; are looking forward to nice business during entire year of 1905.

STARK TOOL CO.: Bright outlook in the near future; inquiries coming in; several orders on hand.

STEEL BALL CO.: Demand for our lubricators great; factory running to fullest capacity; our business growing rapidly, forced to add facilities.

STEFFEY MFG. CO.: Number orders received this month considerable advance over those received corresponding month last year. Prospects very good for 1905.

JOHN STEPTOE SHAPER CO.: Every reason to believe coming year will be a good one.

STERLING EMERY WHEEL MFG. CO.: Quite a change the last week; believe business will improve from now on. Prospects for 1905 bright.

STEWART HEATER CO.: Experienced no depression in business for past four or five years. Confident business will continue for 1905 as in past few years.

D. M. STEWARD MFG. CO.: Our trade increased past sixty days more than 25 per cent.; little doubt of good business for some considerable time in the future.

STOCKBRIDGE MCH. CO.: Very marked improvement past two weeks, inquiries and orders. Several propositions "hanging fire" past year, been closed. Expect gradual picking-up in business generally.

STOEVER FDY. & MFG. CO.: Feel we have reached bottom of present depression, and any change must be for the better.

H. T. STORY: Past summer and fall received more orders than during any previous season. Prospects for 1905 are good.

STOVER ENGINE WORKS: Feel thoroughly convinced have reached the bottom of depression; look forward to one of largest gasoline engine years we have yet experienced.

STOW FLEXIBLE SHAFT CO.: Utterly unable to make forecast for the next year; the hope is that it may be better.

STOW MFG. CO.: Early spring months showed best business we ever had. Decided falling off July, August and September; steady improvement in October which has continued up to date. Everything points to continuation of good business.

STRATTON BROS.: Business past two months up to average for September and October; for past ten months decidedly ahead of first ten months of last year. Expect unusually large trade coming season.

A. STREIT MCHE. CO.: Have more inquiries on hand than at any time before; look for a very good year.

CHARLES A. STRELINGER CO.: Outlook both for immediate present and for the year to come exceedingly good.

C. E. SUTTON CO.: Slight improvement in our business within the last thirty days. Do not anticipate improvement in general business conditions before spring of 1905.

TABOR MFG. CO.: We look for a better year in 1905 than we have yet enjoyed.

THIEM & CO.: All of our business has been good last few years, although have noticed brisk improvement in business for past two months. Our prospects for 1905 very good.

THOMAS & LOWE MCHY. CO.: Have experienced great improvement during past few weeks both as to inquiries and sales, which we consider healthy indication.

THREE RIVERS TOOL CO.: Our business has grown steadily; believe there will soon be very decided improvement in general conditions; looking forward to large business for 1905.

TOLEDO MCHE. & TOOL CO.: Believe we are near end of business depression. See no reason why business should not assume its normal proportions.

TORONTO MCHE. CO.: Note greater volume of business last few weeks; believe business in general will settle down to normal conditions for coming year.

TRANSUE & WILLIAMS CO.: Believe business prospects in 1905 in our line of work very bright.

TRUMP BROS. MCHE. CO.: Quite busy in some of our lines on accumulated orders, but new business not coming in as freely as we should like, for the past sixty days.

W. W. & C. F. TUCKER: 1. Yes. 2. This is the tendency. 3. Very bright.

TURNER BRASS WORKS: Frankly state we do not think as far as business is concerned there is any depression whatsoever. Our prospects for 1905 very bright indeed.

TURNER, VAUGHN & TAYLOR CO.: 1. Yes. 2. Think business will come steady and healthy.

H. B. UNDERWOOD & CO.: Fairly busy during the entire year; have not encountered business depression; have kept on our regular force of employes, and lately have taken on some new ones. Prospects for 1905 very encouraging.

UTICA DROP FORGE & TOOL CO.: Business improved last two months. Outlook is bright.

VANDYCK CHURCHILL CO.: Are looking forward to good, steady, satisfactory amount of business during 1905.

VEEDER MFG. CO.: Have had a very prosperous year indeed and anticipate even a better one next year.

VON WYCK MCHE. TOOL CO.: We personally have experienced a decided improvement in last five weeks. Prospects for 1905 exceedingly bright.

WALLACE SUPPLY CO.: Not noticed any recent improvement; believe, however, bottom of the depression reached and prospects for 1905 are very good.

O. S. WALKER & CO.: While we do not look for a boom, anticipate fairly good business for winter. Prospect for 1905 seems likely to be fully up to the average.

EDGAR T. WARD & SONS: 1. Yes. 2. Improving all the time. 3. Good.

WASHBURN SHOPS: Improvement in business the past month. Are anticipating a good year.

WATERBURY MCHE. CO.: Past month considerable improvement, looking forward to good year's work for 1905.

WATSON-STILLMAN CO.: Our business has received a decided impetus; quietest record in several years July and August; future conditions appear very satisfactory.

WEBSTER & PERKS TOOL CO.: Do not believe we suffered as much as some; certainly anticipate steady improvement in general business conditions. Regard prospects for 1905 as most promising.

WELLS BROS. CO.: Business last four weeks improved somewhat, yet not up to usual standard; indications point to rapid improvement after first of the year.

WESTCOTT CHUCK CO.: Prospects now excellent for continued and increased improvement.

WESTERN TOOL & MFG. CO.: Since the first of month enjoyed marked improvement in trade. Machinery dealers are beginning to stock up, which indicates that trade is picking up with them. Also improvement in our trade with railroads, a good sign of business conditions.

WHITCOMB MFG. CO.: Marked improvement in planer business last few weeks; think business during 1905 and 1906 will be of good volume.

WILEY & RUSSELL MFG. CO.: Haven't observed any great falling off in our business. Very good for this time of year.

WILLIAMS, BROWN & EARL: Business picking up; we have never struck bottom, as this year's business is ahead of last year's business. Looking for great business year.

WILLIAMS TOOL CO.: Trade is somewhat irregular, coming to us in spurts and then laying off for a time, but there seems to be a feeling that 1905 will be the beginning of another prosperous season, and trust it will prove so.

WILMARTH & MORMAN CO.: Shipments for September 10 per cent. better than for August; October 10 per cent. better than September, yet neither month equal to corresponding month year ago; impression is general conditions better, with prospect of good year ahead.

WINDSOR MCHE. CO.: Our business improved somewhat last six weeks; anticipate early improvement over condition existing for the last year; believe our prospects for 1905 good.

WINKLEY CO.: Believe will be a material improvement coming year; are planning according to these ideas.

WOODWARD & POWELL PLANER CO.: Indications are we will have a fair trade this coming year.

C. C. WORMER MCHY. CO.: Feel that depression will be ended in near future, and that after January 1st general conditions will improve.

WORCESTER MCHE. SCREW CO.: From present outlook we expect to be very busy within next three months and with all the business we can possibly attend to.

W. C. YOUNG MFG. CO.: Improvement in business within last sixty days; do not anticipate anything like a boom during coming year; simply a good, healthy business.

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THE NATIONAL MACHINE TOOL BUILDERS' CONVENTION.

The meeting of the National Machine Tool Builders' Association was held at the Hoffman House, New York, November 15 and 16. No action was taken at this meeting in regard to prices, although the subject was discussed in view of the advance in prices of materials entering into the construction of tools. The executive committee were empowered to call a special meeting of the Association to consider the matter further, if this should be deemed advisable before their next regular meeting. Another subject discussed was in regard to placing of large orders by dealers when tools are in good demand, with the possibility of cancellations when there is a drop in the market. It was thought best that no concerted action be taken in the matter, and resolutions were passed simply advocating that the placing of large stock be discouraged, each member, however, managing independently, according to his own personal interests.

In view of the differential tariffs that have been adopted by some foreign countries, particularly Russia, France and Canada, prejudicial to the importation of American machine tools, as a result of American duties on certain products imported from these countries, a committee was appointed to investigate the subject and report to the executive committee, so that a suitable plan of action could be outlined by them for the next meeting.

At the second afternoon session a step was taken which, it is hoped, may eventually lead to the adoption of standard specifications for motor equipments for machine tools. The session was opened by a paper by Fred A. Geier, of the Cincinnati Milling Machine Co. He contended that it would first be necessary to decide upon a standard speed range for variable-speed motors. In milling machine driving a speed range is required at the spindle of from 25 or 30 to 1. By using a motor with a 2½ to 1 speed variation, and then applying double back gears to the machine, this range can be obtained without difficulty; and by using motors with shunt field control, such as are now supplied by electrical manufacturers generally, plenty of speeds can be obtained between gear speeds. The Ward Leonard Co. supply rheostats with from 35 to 120 steps for small motors.

The Cincinnati Milling Machine Co. have standardized the electric drive arrangement for their milling machines, and are prepared to supply them with any one of half a dozen different makes of direct-current, variable-speed shunt-wound motors with a 2½ to 1 variation in speed. This does not completely end the trouble, however, because all of the motors differ in shape and size, so that special parts are necessary in adapting them to the machine. In order to manufacture motor drive parts for machine tools economically, by making them up in lots for stock, motor frames must be standardized in the following respects: 1, size and shape of base; 2, distance from center of driving pulley to center of base; 3, height of motor from bottom of base to center of armature shaft; 4, diameter of armature shaft. The minimum speed of motor should be somewhere below 700 revolutions per minute, and a speed variation of 2½, or at most 3 to 1, would meet the problem satisfactorily. While the advantages of such standardization are at once obvious for machine tool builders, it is believed that they would be as great from the standpoint of the electrical manufacturer, as they would enable him to enter into competition on an even basis with his competitors, and he would be able to make up these motors and carry them in large quantities. The combination of the reduced cost of motor and of tool would materially reduce the now almost prohibitive selling price of motor-driven tools.

At present prospective purchasers of electrically-driven machinery become much discouraged, and often drop the matter, when they find they must wait a long time for delivery. All this would be eliminated by standardization.

W. H. Powell, of the Bullock Electric Mfg. Co., outlined the leading methods of speed control now in vogue. He then stated that in all of these systems, and also where motors are operated at a standard speed, the size and weight of the motor are dependent to a great extent on the minimum speed at which the motor is required to develop its full rated power. The slower the minimum speed the greater will be the size and weight for a given horse power.

As a gear or chain drive is used on motors operating tools the maximum speed of the motor is dependent on the tooth speed of the motor pinion or chain constructed; or upon the maximum ratio of speed reduction between the driven shaft and the motor shaft. The maximum speed of the motor on most machine tools varies from 1,000 to 1,800 revolutions per minute. Assuming 1,500 revolutions as an average value for the maximum speed, Mr. Powell then went on to show how the output of a given size of motor frame and armature core varies with the different methods of speed control. He explained that of the different systems the multiple voltage system would give the greatest horsepower output for a certain size of frame and weight of machine, provided the speed range were the same with all the systems. The multiple-voltage system, however, requires a separate balancing set, and an increase in the number of transmission wires to the motors. There is therefore a demand for variable-speed motors operated on the two-wire system. For this system motors with special commutating poles or compensating coils have been placed on the market with a speed range as high as 6 to 1. A properly designed motor without these special parts can be operated through a speed range of 3 to 1 without undue heating at the lower speeds, and without sparking at the higher speed; but no matter what the design of motor or the method of speed control, the size and weight, and consequently the cost, are dependent on the slowest speed at which the motor is required to develop its full rated power. It is, therefore, desirable to keep the speed range down to a reasonable amount, which in his judgment is 3 to 1, with a minimum speed of 400 to 660, depending on output of motor.

Other representatives of the association and of different electrical companies also made remarks, and finally a committee was appointed to confer with manufacturers of electrical motors and submit recommendations as to standard mounting and dimensions at the next meeting, which is to be held at Washington, D. C.

A feature of the Machine Tool Builders' convention was the special train run by MACHINERY for members and their guests through the entire length of the Subway, luncheon being served on the train at 157th Street. There was a large attendance of machinery manufacturers and dealers on this train, more than twice as many being present as at any previous function for the Association.

A sheet containing an explanation of some of the important facts in regard to the Subway was distributed to the guests, and as these will be of interest to many readers, they are published herewith.

SUBWAY NOTES WORTH PRESERVING.

The general form of the subway is that of the letter Y, with the base at the southern extremity of Manhattan Island, and the fork at 103d Street and Broadway, one branch running up the western side of the city, and the other branch passing beneath the upper end of Central Park, thence in an easterly direction to the Borough of the Bronx.

The main downtown station is at Brooklyn Bridge, from which a single-track loop passes around under City Hall Park, where City Hall station is located.

At Astor Place is a station connecting with the new Wanamaker store, now building. This is destined to be one of the most important trade centers of the city.

At 14th Street is the first express station. At 23d Street the subway station is somewhat novel in that there is provision for underground stores with show windows. At 34th Street the subway goes lengthwise under the Park Avenue tunnel, through which the Madison Avenue surface cars run.

At 42nd Street is the next express station, connecting with the Grand Central Depot. The time required to reach the Grand Central from Brooklyn Bridge by an express train is about 8 minutes. Express trains run through to 96th Street.

At 42nd Street an abrupt turn is made, and the subway passes along 42nd Street to Broadway, thence uptown under Broadway.

At 96th Street (also at City Hall loop) where it has been necessary for the passenger tracks to cross, grade crossings have been avoided by having one track or set of tracks pass under the other at the intersecting points.

From about 125th Street to 133d Street the road emerges and passes over the Manhattan Viaduct. It then tunnels under a height of land to a depth of some 150 feet at the deepest point. Trains now run on this branch to 157th Street, and when the track extensions are completed they will go to Kingsbridge Station, a total distance of 13½ miles from Brooklyn Bridge.

Branch Lines.

The branch running from 103d Street to the Bronx has not been opened to the public, but is so far completed that trains will be run to 145th Street, Manhattan, on this line in about two weeks, and later they will run under the Harlem River to the Bronx. This part of the subway will be of particular interest. The tubes under the river are built up of cast iron segments covered with concrete, the interior diameter being 15 feet. The approaches to the river are of arched concrete construction.

The subway is also being extended south from City Hall Park under Broadway. This is known as the Brooklyn Extension, and will run to South Ferry, thence under the East River to Brooklyn, thence nearly to Prospect Park, connecting with the Long Island Railroad.

Construction.

From Brooklyn Bridge to 96th Street the line has four tracks, then three tracks to 145th Street. On the Bronx branch there are two tracks in the section now building. The Brooklyn extension will also be a two-track line. From Brooklyn Bridge to 96th Street, where the express service is given, the two inside tracks are for express trains, and the two local tracks for local trains. An interesting feature of certain of the local stations is that the grade of the local tracks is raised at the station above the level of the express tracks in order to obtain quick acceleration for the local trains in starting and at the same time maintain a level grade for the express service.

Concrete construction was extensively used in the subway. The typical structure, where the subway is near the surface, consists in a flat roof of concrete supported by I-beams and columns at frequent intervals between the tracks. The side walls are of concrete in which are laid vitrified conduits for the electric cables. This construction is modified according to requirements. In some cases concrete arches are used and in others reinforced concrete construction. To make the structure impervious to moisture, there has been laid beyond the side walls, under the floor, and over the roof a course of felt washed with hot asphalt. Where tunnelling at a considerable depth was necessary, concrete lining was generally employed.

The track construction is of the usual standard with broken stone ballast, timber cross ties, and 100-pound rails. It is to be noted that the third rail is protected by an overhead guard.

The subway stations were the pride of the city before they were disfigured by the advertising signs placed in them by the operating company. The color effects of the tiling, the varied designs of the different stations, the attractive ceilings, the light and spacious appearance of many of the stations, make them unusually attractive, and the intention was to so modify the decorative design as to enable one to recognize a station by its appearance as well as by the conspicuous signs erected at each station.

Power House.

The power house for operating the subway trains—the largest steam plant in the world—is on the west side of the city, between 58th and 59th Streets. The plant provides for a single row of large vertical engines and electric generators, aggregating 100,000 horse power at normal rating. A sectional scheme was adopted for the plant, each section comprising one chimney, twelve boilers, two engines with generators, condensing equipment, etc. Four of these sections are contemplated, and in addition a steam turbine outfit is in operation, consisting of three turbines of about 2,000 kilowatt capacity.

Cars.

The subway cars are a modification of the type that has been used on the elevated roads of New York City. These have the motorman's compartment located on the platform. The side of the compartment is formed by a door which can be placed in three positions: (1) to separate the cab from the rest of the platform, (2) to close the opening at the rear of the car, in which position it is placed on the rear platform of the train, and (3) swung back to enclose the controller, in which position it is left on all the platforms except the front and rear, so that the entire space is available for the ingress and egress of passengers.

The platforms have doors instead of gates arranged to slide into pockets in the side framing. The side walls of the cars incline inward slightly toward the top. The lower sashes of the windows are fixed to prevent passengers from injury by leaning out and coming in contact with the subway posts; the upper sashes, however, can be lowered.

A part of the rolling stock consists of steel cars designed to be fire- and "collision"-proof. The interior finish of these cars is largely of aluminum, and while it lacks the beauty of the mahogany finish of the wooden cars, this objection may be offset by the sense of safety felt by the passengers.

The motor equipment of the cars is unusual. A train of eight cars is equipped with motors aggregating 2,000 horse power, and in consequence a high degree of acceleration is obtained. The rate of energy absorption in starting these trains is not far from double that taken by the heaviest trains on steam roads when starting from stations. By the use of the multiple-unit system of electrical control, the motors on the several cars are operated from the controller at the front of the first car. In an eight-car train, the first, third, fifth, sixth and eighth cars will be motor cars, which arrangement enables the train to be shortened by uncoupling cars from the rear.

Lighting.

The subway is lighted independently of the current operating the trains. It is for this purpose that the steam turbines in the power station are employed. This arrangement was made in consequence of the accident in the subway of Paris in 1903, when, owing to a collision, the tunnel was in total darkness. The lamps in the subway itself are so shielded that their glare will not blind the motormen.

Signals.

The trains are protected by an electro-pneumatic block and interlocking system, which has been worked out to a degree of perfection probably not before attained. The plans for the operation of trains contemplate local trains at one-minute intervals, and express trains at two-minute intervals. This means that so many thousand people will be traveling in the subway with trains near together that it would not be safe to entrust their lives entirely to the motormen. The signals are there-

fore connected with pneumatic stop levers which rise beside the right-hand rail of each track when a signal is set against a train, and if the motorman should allow his train to pass the signal the current would be shut off automatically and the brakes applied. The length of blocks was determined by many careful experiments upon the length of track required for a train to stop with the brakes applied. Instead of the "home" and "distance" signals as usually employed on steam roads, the so-called overlap system of signaling is used, by which a train that has stopped is always protected by two home signals in the rear, indicating an absolute stop, and three caution signals in addition to the automatic stop at the second home signal at the rear of a train.

* * *

NOTES UPON BALANCING HIGH-SPEED MACHINERY.

In the article upon the shop methods of the De Laval Steam Turbine Company in the November number was an illustration of a machine for the accurate balancing of the rotary parts of turbines. Reference was made in the article to the so-called "critical speed" of bodies rotating with high velocity and the purpose of what is here written is to explain this and certain other points connected with the subject of balancing.

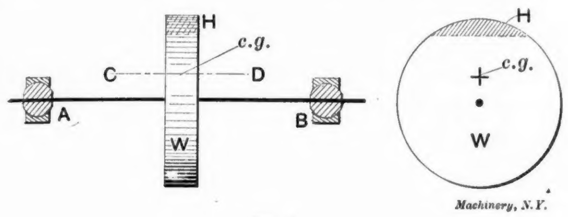


Fig. 1.

In Fig. 1 is a disk W mounted on a shaft A B turning in ball-and-socket bearings, as indicated. One side of this disk is supposed to have a dense section at H, making it heavier than the opposite side. The center of gravity of the wheel, therefore, will lie to one side of the shaft A B, say on the axis C D. Now if this shaft and disk be rotated, the centrifugal force generated by the heavier side will be greater than that generated by the lighter side diametrically opposite to it, and the shaft will deflect toward the heavy side, as in Fig. 2, causing the center of the disk to describe a small circle, indicated by the dotted line at a. To locate the point at which a weight should be added, or on the other hand, at which metal should be drilled out in order to bring the piece into balance, a piece of chalk is held so that the high side of the disk will just touch it as it comes around. The weight necessary to balance, to be told by trial, is then added opposite to the high side where the mark appears; or else, if the balancing is to be done by drilling, metal is removed on the same side with the mark. In the most accurate balancing it is advisable to use a steel point held rigidly, but which can be fed up gradually until the point makes a faint scratch on the edge of the disk.

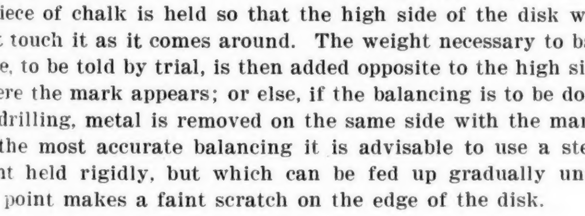


Fig. 2.

The foregoing conditions hold until a comparatively high speed is reached, depending upon the weight of the disk and flexibility of the shaft. A point will eventually be reached, however, at several thousand revolutions a minute, when there will momentarily be excessive vibration, and then the parts will run quietly again. The speed at which this occurs is called the critical speed of the wheel, and the phenomenon itself is called the settling of the wheel. The explanation is that at this speed the axis of rotation changes and the wheel and shaft, instead of rotating about their geometrical center, begin to rotate about an axis through their center of gravity, or about the axis C D in Fig. 1. This is illustrated in Fig. 3, where the wheel and shaft have taken a new position in which the axis C D, if extended, would pass through the centers of the two bearings, while the shaft is deflected so that it traces a circle shown by the dotted line b in Fig. 3. It is to be noted, however, that this circle is now on the H, or heavy, side of the disk instead of on the other side as before, so that now if one were trying to locate the point where weight should be added in order to balance the disk, he would find that the chalk mark came on the light side of the disk, and that the weight should be added on the same side.

Mr. Konrad Anderson says,* It is supposed that the settling of a rotating body occurs when the number of revolutions is equal to the number of vibrations which the shaft makes with the wheel mounted upon it. That is, a shaft and wheel have a

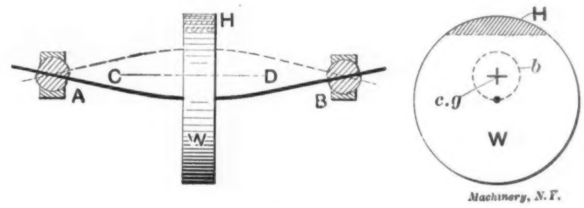


Fig. 3.

certain time of vibration, just as does a pendulum or spring, and when this synchronizes with the time of rotation the change is supposed to occur. In the De Laval turbine the flexible shaft and wheel are in such proportions that the settling takes place very quickly, and the critical speed is from 1-5 to 1/8 of the normal number of the revolutions of the wheel. Mr. Anderson gives the following empirical formula for determining the critical speed, in which C is a constant to be found by experiment for wheels and shafts, or other rotating parts of a certain design. Having determined the constant for one size he finds the formula to apply very nearly to every size of similar proportions.

n = critical speed.
P = force in pounds to bend shaft a certain distance.
Q = weight of turbine wheel.
C = constant.

$$n = C\sqrt{\frac{P}{Q}}$$

In referring to the subject of balancing, Francis Hodgkinson states† that "in the cases of heavier and bigger bodies, which would have a lower rotative speed, the marks do not come exactly on the light side. They may sometimes come as much as 90 degrees ahead of the light side. The exact angle can

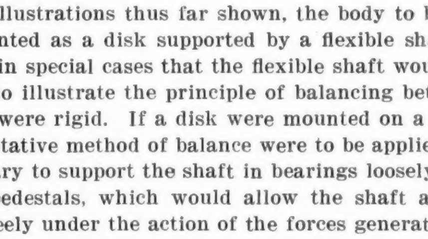


Fig. 4.

only be found by experiment, and at best this is only a cut-and-try method. With experience, however, work may be put in very accurate balance."

In the illustrations thus far shown, the body to be balanced is represented as a disk supported by a flexible shaft. While it is only in special cases that the flexible shaft would be used, it serves to illustrate the principle of balancing better than if the shaft were rigid. If a disk were mounted on a rigid shaft and the rotative method of balance were to be applied, it would be necessary to support the shaft in bearings loosely connected to their pedestals, which would allow the shaft and disk to vibrate freely under the action of the forces generated.

In attempting to balance a cylinder, like Fig. 4, the heavy section is likely to come at or near one end, as shown at H, and there might, in fact, be another heavy spot diametrically opposite at the other end, as at H', so it is obviously better to divide the cylinder into a number of disks, A, B, C, D, etc., and balance each one separately. This is not always possible, however, as in the case of the running parts of electric

* Trans. Inst. Eng., Shipbuilders in Scotland, Nov., 1902.
† Proc. Eng. Soc., West Pa., Nov., 1900.

generators, for example, in which the winding is liable to throw it out of balance. The only way with such parts, which are usually of a cylindrical shape, is to mount them in loose bearings, as mentioned above, and run them up to speed by belt or other available means. There was published in MACHINERY for August, 1899, a description of an apparatus for this method

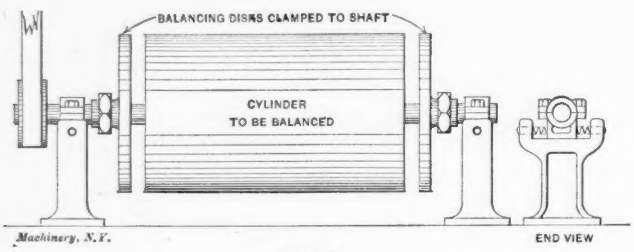


Fig. 5.

of balancing that has been used in balancing the cylinders of wool carding machines which run at a speed of about 1,000 revolutions a minute. The plan is illustrated in Fig. 5. The cylinder to be balanced is carried by a shaft supported by bearings loosely attached to their pedestals, and are preferably held to a slight extent by springs, although these were not used in the original design. On each end of the shaft is a carefully-balanced disk having a taper, split sleeve on which screws a taper nut, for the purpose of clamping the disk to the shaft in any desired angular position. Two diametrically opposite holes are drilled near the edge of each disk for the purpose of attaching balancing weights. When the cylinder is run at speed the end that is out of balance will throw out and is marked with a piece of chalk. The cylinder is then stopped and the disk at that end moved around until one of the holes comes opposite the mark, when a weight of what is thought to be the right size is attached and another trial is made. After repeated trials for each end of the cylinder the correct running balance is attained and then balance weights are made, weighing the same as those attached to the disks, and fastened to the cylinder in the same relative positions occupied by the weights on the disk. By this method there is no difficulty in applying the appropriate weight to the correct end of the cylinder.

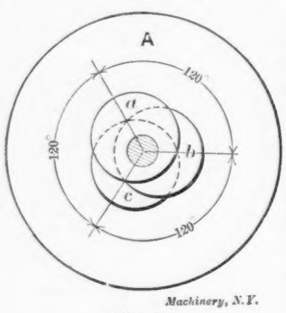


Fig. 6.

Some years ago William Sellers & Co., Inc., Philadelphia, conducted a series of tests upon an experimental steam turbine, similar in principle to the present Curtis turbine. As the disks rotated at very high speed, some convenient method of balancing was sought and the plan illustrated in Fig. 6 was originated. This will be the last to which reference will be made in the present article. In the figure *A* is the disk to be balanced and *a*, *b* and *c* are three thin disks turned up in the form of eccentrics and mounted on the shaft with the main disk. The bore of the eccentric was a close fit on the shaft, so there will be some frictional resistance between the eccentrics and the shaft; yet they were not so tight that it was necessary to drive them in place. The eccentrics were spaced 120 degrees apart and as the main disk attained its speed the eccentrics gradually shifted, automatically, until they reached such positions that apparently brought themselves, together with the disk and shaft, into perfect running balance. Just why the vibrations of the shaft were such as to cause this behavior of the eccentrics is a problem for the mathematicians to handle, but such is the fact, and we will leave it for others to explain.

* * *

F. B. Bristol, of the Bristol Co., Waterbury, Conn., was killed in an automobile accident on the evening of November 21. Mr. Bristol had been delayed at the works and wishing to gain time started for his home in his automobile at a high speed. He collided with a train while crossing the tracks at Platt's Crossing and was killed. Mr. Bristol was 45 years of age.

A LOST (?) INVENTION.

"Fame and fortune await the lucky individual who can rediscover the combination of metals from which the Egyptians, the Aztecs and the Incas of Peru made their tools and arms. Though each of these nations reached a high state of civilization, none of them ever discovered iron, in spite of the fact that the soil of all three countries was largely impregnated with it. Their substitute for it was a combination of metals which had the temper of steel. Despite the greatest efforts, the secret of this composition has baffled scientists and has become a lost art. The great explorer Humboldt tried to discover it from an analysis of a chisel found in an ancient Inca silver mine, but all that he could find out was that it appeared to be a combination of a small portion of tin with copper. This combination will not give the hardness of steel, so it is evident that tin and copper could not have been its only component parts. Whatever might have been the nature of the metallic combination, these ancient races were able so to prepare pure copper that it equaled in temper the finest steel produced at the present day by the most scientifically approved process. With their bronze and copper instruments they were able to quarry and shape the hardest known stones, such as granite and porphyry, and even cut emeralds and like substances. A rediscovery of this lost art would revolutionize many trades in which steel at present holds the monopoly. If copper could thus be tempered now its advantage over steel would be very great and it would no doubt be preferred to the latter in numerous industries. It is a curious fact that though this lost secret still baffles modern scientists it must have been discovered independently by the three races which made use of it so long ago."

The above item from a Sunday paper is an example of many such floating about which both reflect and impress an exaggerated sense of the importance of a so-called lost invention or art. The writer says: " A rediscovery of this lost art would revolutionize many trades in which steel at present holds the monopoly." Why would there be any revolution? Is any man sighing for a copper razor, or does any boy want a brass jack-knife blade? There is no evidence to prove that the tempered copper tools of the ancients were capable of holding a keen edge like steel; on the contrary they were probably very crude and unsatisfactory substitutes for what we now have. As a matter of fact there is no difficulty in making hard alloys. The United States Government Board, appointed twenty-five years ago to test iron, steel and other metals, reported through their chairman, Prof. R. H. Thurston, in that portion relating to copper-tin alloys that alloys of copper 72.89, tin 26.85, tin 29.88, copper 68.58, tin 31.26; copper 67.87, tin 32.10; and copper 65.34, tin 34.47 were all so hard that they could not be turned in a lathe with steel tools. These and other hard combinations have been generally known to the trade for years, but of what good are they? Copper and its alloys are more costly than the ordinary grades of tool steel, and the only apparent advantage possessed is that they are incorrodible. It is difficult to understand that this would be the cause for any revolutionary change, and we are forced to the conclusion that such statements are what, in current slang, is known as "hot air."

* * *

In common with other affairs of life some of the most simple and apparently obvious facts of steam engineering have only been learned after long experience and endeavor in a contrary direction to natural laws. Years ago before the days of the distillers on board ship for supplying fresh water to the boilers it was the practice in the United States Navy to use salt water for the "make-up," *i. e.*, to supply the water lost by leakage and other wastes. The rule was never to allow the salinity of the boiler water to exceed 1½ per cent of saturation. But, of course, it happened more than once that this rule had to be broken on account of leaky boilers, stress of weather or other reasons which make it impossible or unsafe to blow off and replace with sea water. Under such circumstances the surprising result was always noted that the scale deposits were more friable and easily broken loose from the sheets and tubes so that cleaning the boilers was an easier task than when the salinity had been kept down to the prescribed percentage. The reason, of course, was that when the salinity was kept at a low percentage more sea water had to be pumped into the boilers which introduced more lime and other scale-making properties. The lime being thrown down at once, formed a hard insoluble scale that could be removed only with difficulty. With less seawater introduced less lime was deposited, hence less scale.

IRON AND ITS EARLY MANUFACTURE IN ENGLAND.

A. R. BELL.

That iron was first worked by the Phœnicians is only a probable conjecture, but they were, we are told, skilled in metallic ores, and proofs remain of their having worked the tin mines in Cornwall. There is every evidence, however, that iron was worked in England during the time it was occupied by the Romans, and during the Danish settlement in England the art of manufacturing iron was much improved. It appears malleable iron was made during that period in a footblast furnace, Fig. 1, the simplicity of which is interesting, showing what may be effected by very limited means. The excellent quality of the iron turned out from these rude furnaces compares favorably with that now supplied by the great iron works possessing huge capital and extensive laboratories, for when the art was but little advanced the most tractable ores were selected and charcoal was invariably used as fuel, circumstances which in themselves are sufficient to account for the iron being of high quality. Each furnace measured about 8 by 16 inches at its mouth, and was about 3 feet deep, terminating in the form of a funnel over a shallow pit inclining outward. The furnaces were constructed in a bed of clay about 3 feet high and 3 feet wide, against which a light wall about 10 feet in height was raised to protect the bellows and the furnaceman located immediately behind. Each bellows consisted of a circular rim of wood about 6 inches in diameter and nearly 2 inches high,

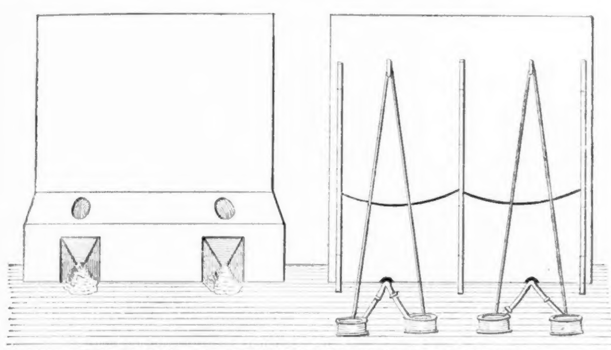


Fig. 1. An Early Form of Foot Blast Furnace.

fixed on a clay floor and covered with cowhide, with a hole in the center to admit air and to receive a cross stick fastened by a cord to an elastic stick above. Each pair of bellows was worked by a boy, who rested his back against a rope for the purpose of support and stepped alternately from the orifice of one bellows on to that of the other, at each step forcing a blast of air into the furnace through a tube of bamboo. The furnaces were charged with a mixture of charcoal and iron ore broken into small pieces. The fires were kept as strong as possible until the ore was reduced and the fused metal collected in a cake on the ash-pit.

At the time when separating the metal by footblasts was in vogue, the art of casting iron was unknown, or at least not practiced, but in the sixteenth century blast furnaces were of a sufficient size to produce, with ores and the charcoal of wood, from two to three tons of pig iron per day. This output, however, was only attained in suitable situations and where water power was available, while the greater part of the ore was made into bar iron in a refinery; at the smaller works it was made malleable before being withdrawn from the furnace. When wood became scarce, pit coal was substituted for making pig iron. Mr. Simon Sturtevant in 1512 had a patent granted him for this purpose, but the process proved to be unsuccessful. It is strange that although pit coal was known long before this period and large quantities were shipped to Holland and Belgium, where it was used in the smith's forge and in other manufactures, yet in England the prejudice against its use in the manufacture of cast iron was so keen that when it was first proposed every obstacle that could be devised was brought in its way, consequently none of the adventurers who attempted to use it were successful. In 1619 Captain Buck, Major Wildman, and others constructed air furnaces in the Forest of Dean, in which they placed large clay pots for containing the requisite preparations of ore and charcoal, the flame of pit coal being employed for heating the furnaces. It was expected that by tapping the pots below, the separated metal would flow out, but it was found that the heat was not sufficiently intense to produce an entire separation of the metal, the pots cracked, and the work was abandoned. At this time the price of iron was advancing in consequence of many of the iron works having stopped for want of fuel, and those who were able to obtain supplies of

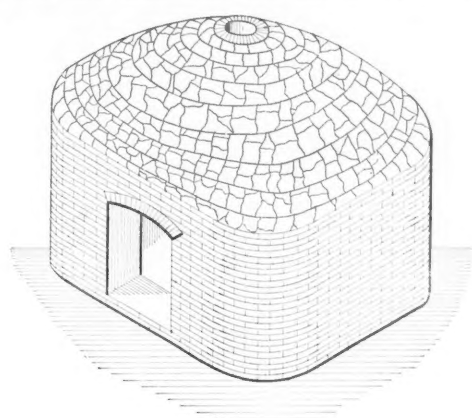


Fig. 2. Early Form of Coke Oven, Beehive Pattern.

wood were making high profits from the manufacture. Dudley in his "Metallum Martis" states that his father and himself had smelted iron with coke in large quantity, but that Oliver Cromwell and several of his favorites, who wished to become partners and were refused, ruined the establishment. The brittle quality of English bar iron, made from coke at this period, and the great expense of that which was made from charcoal, owing to the increasing scarcity of wood, were most likely the causes of the great decline in the home manufacture which then took place, and importations from Russia and Sweden were made on a large scale. Later the steam engine afforded the British manufacture a means of renewing the industry; the small furnaces supplied with air from bellows

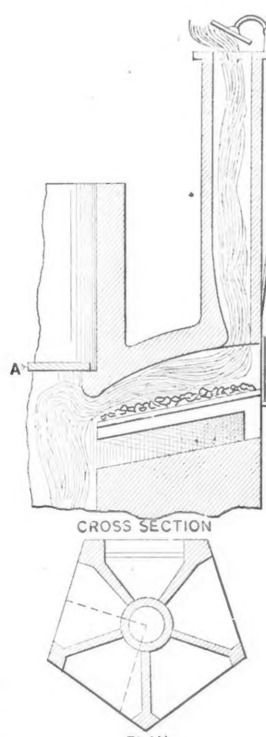


Fig. 3.

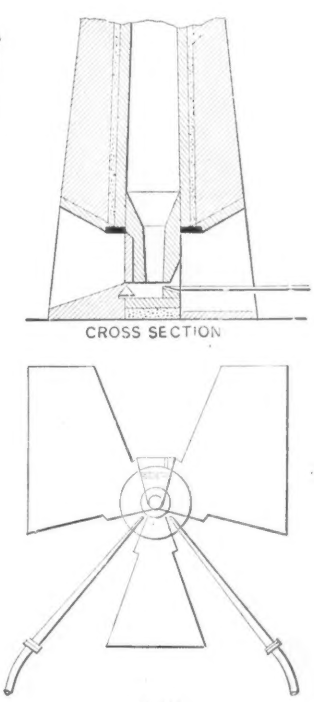


Fig. 5.

worked by oxen, horses or men were given up, and larger furnaces were introduced with blowing machines to make an increase of the column of air and effect a more complete combustion. Experience also proved that the produce of the furnace could be increased by enlarging the diameter of the steam cylinder and rendering the vacuum therein more perfect.

The making of coke was performed on a rectangular-shaped hearth prepared by beating the earth to a firm flat surface and padding it over with clay. On this the pieces of coal were piled inclining one to another, those of the lowest layer being set so as to touch the hearth with the smallest surface. The piles were usually from 30 to 50 inches high and from 9 to 16 feet square, and contained from 40 to 100 tons of coal. Vents were left reaching from top to bottom into which burning fuel was thrown, and were afterward closed by pieces of coal driven firmly in; thus the kindled fire was forced to creep along the bottom and eventually burst out at the sides. If the coal contained pyrites the combustion was allowed to continue after the smoke had disappeared to extract the sulphur. The fire generally lived from 60 to 70 hours, but the coke was not removed for at least 12 and sometimes 14 days. The annoyance attending this process by the evolution of the immense quantities of smoke and the tremendous waste of volatile products induced Lord Dundonald in 1781 to improve the system, and he introduced what were known as tar works. The ironmasters sent the raw coal to the tar works and received in return coke, the "tar works" being compensated for their trouble by retaining the valuable commercial products, tar-pitch, varnish and ammonia. Coke kilns, or ovens, were first introduced near Sheffield about 1840. They were hemispherical or beehive in shape (see Fig. 2), about 10 feet in diameter at the base and about 2 feet at the crown with a circular opening at the top for introducing the coal, and once heated, were allowed to burn day and night without interruption. The method of charging a coke oven was as follows: Sufficient small coal was thrown in at the top

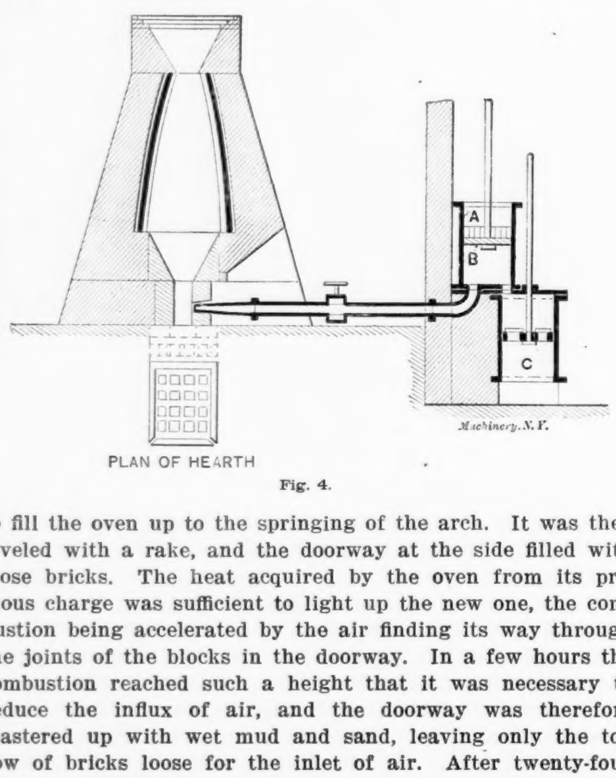


Fig. 4.

to fill the oven up to the springing of the arch. It was then leveled with a rake, and the doorway at the side filled with loose bricks. The heat acquired by the oven from its previous charge was sufficient to light up the new one, the combustion being accelerated by the air finding its way through the joints of the blocks in the doorway. In a few hours the combustion reached such a height that it was necessary to reduce the influx of air, and the doorway was therefore plastered up with wet mud and sand, leaving only the top row of bricks loose for the inlet of air. After twenty-four hours of burning this inlet was also closed, and only the chimney remained open until the flame was dead, when a few loose stones were laid over the aperture at the top, and covered up with a thick bed of mud. All was then air-tight and was allowed to remain in that condition for about twelve hours to complete the operation, after which the doorway was opened and the coke raked into iron barrows for its removal.

The process of roasting iron previous to smelting in a furnace, seems to have been introduced mainly by Mr. Teague, of Calford, Gloucestershire. He took out a patent in 1832 for smelting iron, in which he proposed to economize by roasting the ore, and instead of the calcination being a distinct process, he combined the operations of roasting and smelting. For this purpose he constructed around the chimney shaft near the top a series of four small reverberatory furnaces, each provided with a damper at the top, and a lateral door which opened outward. Through these doors the ores to be roasted were introduced on to iron plates, which formed the bottom surface. The ascending flames from the smelting furnace were prevented from passing out vertically, as usual, by means of a trap door, *A*, as shown in sketch, Fig. 3, this causing the hot gases to pass through the oven and impinge on the ore, thus depriving it of its volatile combinations. When the ores were sufficiently operated upon they were thrust forward into the smelting furnace, and while the roasting furnaces were being recharged, the trap door,

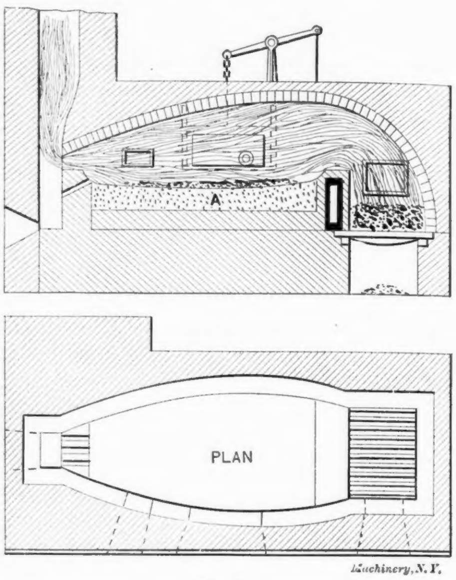


Fig. 6.

A, was open to the shaft so that the flames might ascend directly by it. An early form of smelting furnace introduced by Mr. David Mushet is shown in Fig. 4, the external form being that of a truncated pyramid. This type of furnace differs in no essential details from the present-day one, excepting in the blowing machinery. The regulating cylinder shown at *A* was about 8 feet in diameter, and the floating piston, *B*, was loaded with weights varying according to the power of the blowing engine. The blowing cylinder, *C*, was about 6 feet in diameter and 7 feet stroke. The following leading dimensions of the furnace will be of interest: The hearth was about 2 feet square at the top of the boshes, the furnace was about 12 feet in diameter and about 8 feet high. The top of the furnace was about 3 feet in diameter, and the internal cavity of the furnace from the top of the boshes was about 30 feet high. The plan of the foundation, built of stones and bedding sand, is shown. To start the furnace loose fuel was thrown in at the bottom and a few baskets of coke introduced to become thoroughly ignited; the cavity was then gradually filled. The first charge received but a small portion of iron-stone compared with the weight of coke,

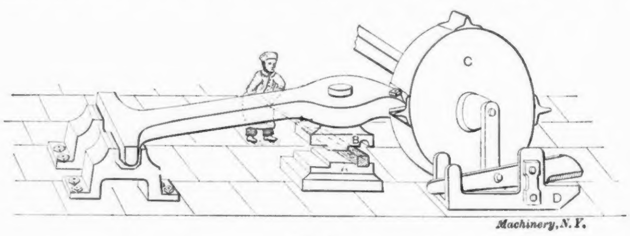


Fig. 7.

but after a few days the iron-stone was gradually increased in proportion, and when once started these furnaces were allowed to burn for several years. For smelting by means of anthracite coal, Mr. Mallin invented the furnace shown in Fig. 5. For his experiments he used a hearth of only 11 inches in diameter at the tuyeres, the blast being introduced as represented in the plan. He found that the blast required to work the furnace had to be under a pressure of at least 2½ pounds to the circular inch, and the quantity of air required for an ordinary furnace would not be less than 28,000 cubic feet per minute. At one time the prejudice against the use of anthracite was very strong, and it was used for a long

time in parlor and kitchen grates before it gained the attention of iron masters. The first attempt of puddling iron for depriving it of carbon and oxygen to render it malleable, was carried out in a furnace illustrated by Fig. 6. At *A* a basin of sea sand was spread in a concave shape supported by bricks on solid masonry, and on this bed of sand the metal was placed and exposed to the heat of the flames. The amount of air was regulated by dampers.

In Fig. 7 is shown an early form of shingling or blooming hammer, consisting of an anvil, *A*, with its block. On to this the shingler drew out of the furnace a stout flat bar, the end of which was brought to welding heat, and laid on the ball under the hammer, *B*, where they were welded and formed into one piece. The shingler was then enabled to turn the ball about upon the anvil, and meet every blow of the hammer, while the drum, on which were fixed four wipers or cogs, revolved, causing the hammer to be lifted, and then allowing it to fall by its own weight. The face of the hammer, it will be noticed, was not flat, but had channels and projections, and placing the bloom under these projections cross ways caused it to extend, or if placed in the other direction its breadth was increased. Attached to the crank at the side of the drum, was a pair of shears, as shown at *D*, used for cutting off the rough edges on the blooms. It sometimes happened through mismanagement on the part of the puddler that the bloom was not sufficiently freed from impurities for treatment under the hammer, and its indisposition was shown by a hissing or bubbling. It was then thrust back to the puddler, and he had to pay a fine for his carelessness in drawing it out of the furnace too early.

* * *

ELECTRIC REPAIRING.

THE COMMUTATOR.

NORMAN G. MEADE.

Norman G. Meade.

The most economical method of repairing electrical machinery in a manufacturing establishment, or electric railway plant, is a subject that should command the attention of the superintendent and electrician. The exorbitant charges of electrical repair concerns and the unnecessary delay in transportation of apparatus make it a practical necessity for companies of any magnitude to do their own repairing. In the present article a few suggestions are given for re-filling commutators. As the commutator is the part of a direct-current machine that is subjected to the greatest wear, its re-filling constitutes a large portion of the repairman's work.

It is always advisable, when possible, to purchase hard-drawn copper strips, drawn to gage, and cut them to required lengths. Old commutators are frequently so far out of date that standard sizes of segments will not do. A very good commutator can be made from a copper casting, similar in shape to the assembled commutator, that is, cylindrical in form and enough larger than the original commutator to allow for finishing, Fig. 1. Large castings may be cored out at ends, *a* and *a'*, for collars, thus saving some stock and considerable labor, as it is then only necessary to make a finishing cut after segments are assembled. Bore out the rough casting and drive it on an arbor and place in "centers" of a milling machine. Use a 1-16 inch saw about four or five inches in diameter. Cut as many slots in the casting as there are to be segments, *b*, Fig. 2. By using an indexed head this is a very simple process. Cut the slots to within about 1-8 inch of through, as shown at *c*. The slots for armature leads should be cut in after the commutator is assembled and turned. Now, drive out arbor and catch casting in a vise and finish cutting through the slots with a hack-saw. Two blades put in the frame at the same time will make a cut about equal in width to that made by the saw in milling machine. File off any burrs that remain on segments and drill a hole in each one on flanged portion *a*, Fig. 3, in diameter about twice the width of slot cut for lead wires, and a little deeper. This hole aids greatly in soldering in armature leads, as the solder flows at once to the bottom of slot. The insulation between the segments should be micanite about 1-32 inch in thickness. As the segments are sawed up by a 1-16 inch saw, the rough casting must be made large enough to allow for the difference.

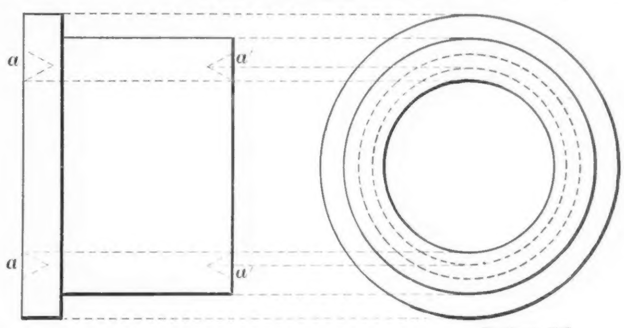


Fig. 1.

For instance, in sawing up a casting into 32 segments, two inches of the circumference would be wasted. Using 1-32 inch micanite would make up for one inch only, so that the rough casting must be one inch greater in circumference—over and above the stock allowed for finishing—than the original size of the old commutator.

The next step is to assemble the segments in a suitable clamp, as shown in Fig. 4. This is a cast-iron split ring, the two parts, *c* and *c'*, being held together by bolts *d* and *d'*. A plan of section *c* is shown; *a* and *a'* are dowel pins, and *b* and *b'* are clearance holes for bolts *d* and *d'*. Great care must be taken in assembling the segments to have them all straight, that is, parallel with the axis of the commutator. Now, chuck the clamp, with the segments, in the lathe, and bore out the center to required diameter, then bore out the ends to correspond with the old commutator. A templet of tin made to fit the end bore of the old commutator is very convenient for gaging the new one.

It is more economical to make several commutators at one time, so that a temporary shaft, with collars and clamping nuts, should be provided. Such an arrangement is shown in Fig. 5, *d* being a short length of cold-rolled steel threaded at

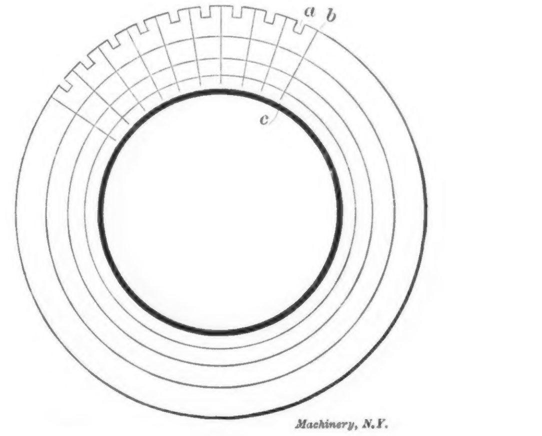


Fig. 2.

e and *e'*; *a* and *a'* collars bored out to slip over shaft, and *b* and *b'* clamping nuts. The temporary shaft should be firmly secured to the newly-bored segments before removing the clamping ring. This done, the ring may be removed and the new commutator will be ready for turning, as shown in section at *c* and *c'*, Fig. 5.

Before turning, the commutator should be heated until the shellac oozes from the micanite, then placed on end on a surface-plate with a hole for shaft to extend through. This plate is shown at *d*, Fig. 6.

Place a try-square on the plate and sight along the blade

NORMAN G. MEADE was born in Philadelphia in 1876. He has worked for the McIntosh & Seymour Co., the Auburn Light, Heat and Power Co., and the Hamilton-Corliss Engine Works in the capacity of electrician. His specialty is electrical engineering and electrical equipment of manufacturing plants.

to see that the edge of one of the segments coincides with it, as at *b* or *c*. If not, by using a small cold-chisel and hammer, drive the segment one way or the other until plumb. Go all around the commutator in this manner. After straightening all the segments, tighten up the clamping nuts again and allow the shellac to dry. After the finishing cut is taken, the com-

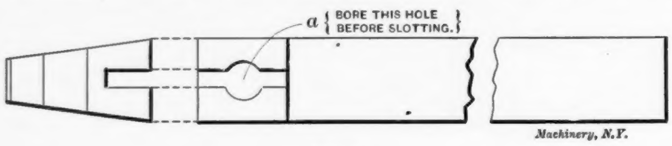


Fig. 3.

mutator should be returned to the milling machine and the slots cut for lead wires, as shown at *a*, Fig. 2. When all burrs have been removed, we are ready to put on the retaining band, which firmly holds the segments in place until used.

Fig. 7 shows a method of putting on the band. The segments, *a*, are placed between lathe centers, and a heavy piece of manila paper is wrapped around them, as shown at *e*.

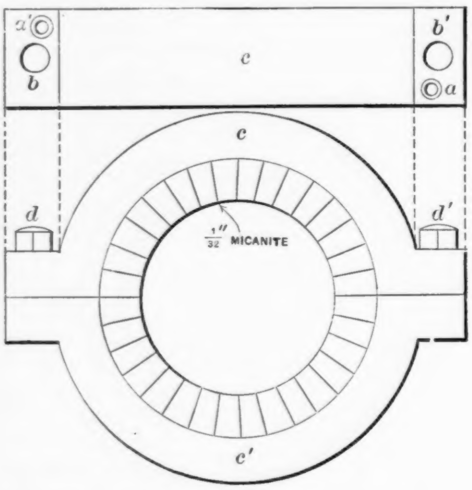


Fig. 4.

This is held in place temporarily by a cord, which also serves to hold in place a piece of 1-32 inch brass, *b*. Now cut two fiber friction blocks, *f* and *f'*, to fit in the toolpost, bore a hole and insert a pin in each, *g* and *g'*, to keep the blocks in place. Any amount of tension can be placed on the blocks by the clamping screw *n*.

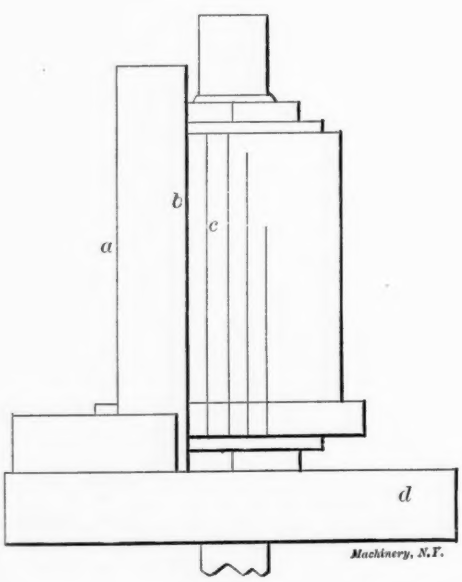


Fig. 6.

Take the end of a coil of No. 16 brass wire, and pass it between friction blocks, *f* and *f'*, and catch it in one of the slots, as at *c*. Turn the assembled segments two or three revolutions until the wire is brought over the paper *e*, then cover about one-half the length of the segments closely and very tight. When the desired amount of wire has been wound on, turn the ends *i* and *i'* of the brass strip *b* over on wire, and hammer down, bringing the turn *h* close up to the band. Flow solder over the band with an iron and cut off the ends of wire. The commutator may then be removed from temporary clamping device, when it will have the appearance shown in

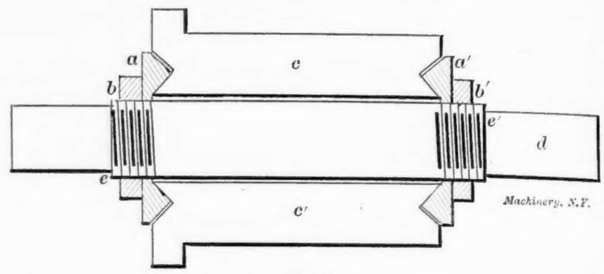


Fig. 5.

Fig. 8. A temporary clamping device, the clamping ring, and templets, can be used indefinitely. One clamping ring can be used for several sizes of commutators by using split bushings.

When removing old segments from a commutator, care should be taken to keep the molded mica insulation on the ends intact. If this is broken it can be replaced by canvas

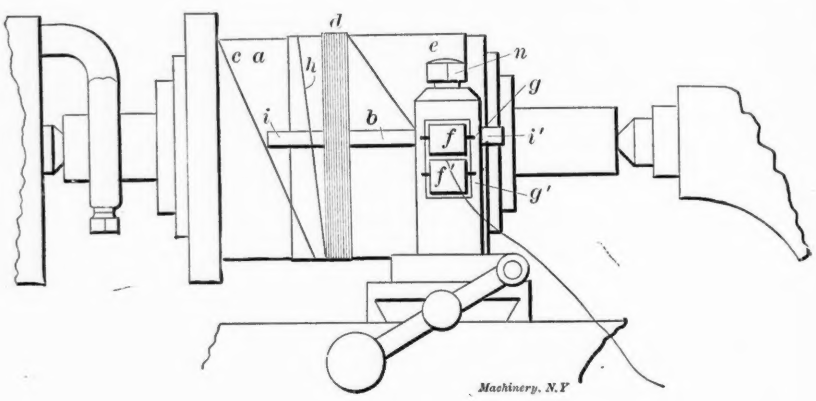


Fig. 7.

disks, shown in Fig. 9, made up of several pieces shellaced together to obtain a thickness equal to the molded mica. Place the old commutator sleeve, with the rear collar attached, end down on a bench and slip the canvas disk over sleeve to bottom. A hole in the disk should fit tightly over the sleeve, and the outside diameter be about one inch greater than that of

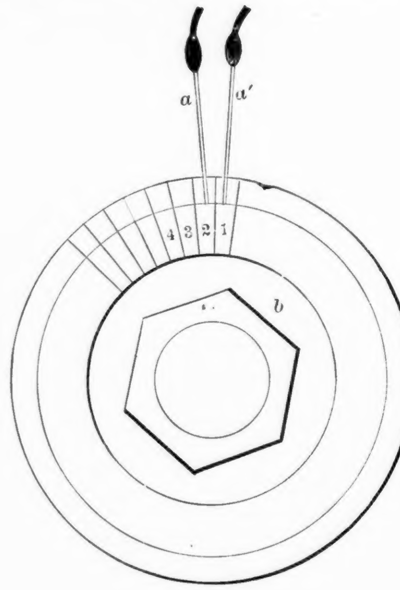


Fig. 14.

the commutator. A thin sheet of flexible micanite must be wrapped around the commutator sleeve, to insulate it from the inside of segments. After placing the assembled segments *b*, over the sleeve, slip on the upper canvas disk *a*, Fig. 10, then collar *b*, finally tightening up nut *c*. Canvas disks should be put in with shellac, wet. After screwing up the nut firmly,

allow all dampness to dry out thoroughly. The canvas disks will then protrude between collars and segments as shown at *a*, Fig. 11. Trim off smoothly, giving a finished appearance like *a* in Fig. 12.

The completed commutator is now ready for testing. A very convenient and fairly accurate method is shown diagrammatically in Fig. 13. A sixteen candle-power incandescent lamp is connected in series with the mains, and two flexible cords with solid copper tips, *b* and *b'*. Fig. 14 shows the application of the testing arrangement. The copper tips, *a* and *a'*, are placed on adjoining segments, as at 1 and 2. If there is a short-circuit, the lamp will light. Test each segment in turn in this manner. Then, by placing one of the tips on the end of the collar, as at *b*, and touching the other to each segment in turn, any leakage from segments to core will be found. If no leak is found the commutator is ready for use.

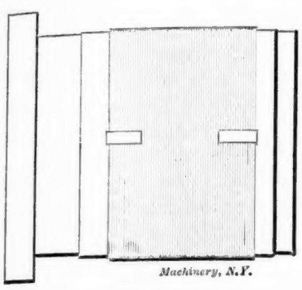


Fig. 8.

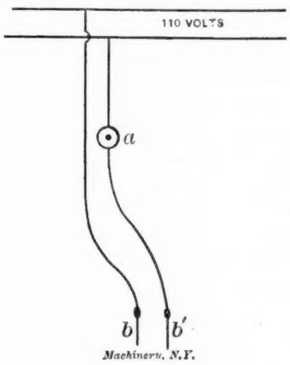


Fig. 13.

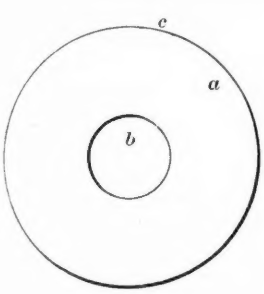


Fig. 9.

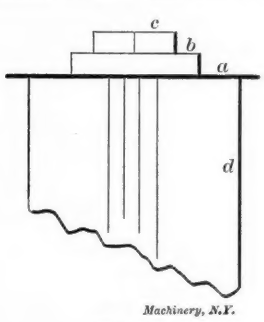


Fig. 10.

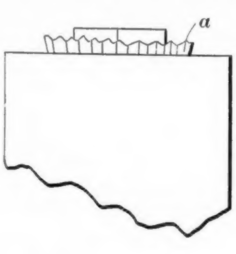


Fig. 11

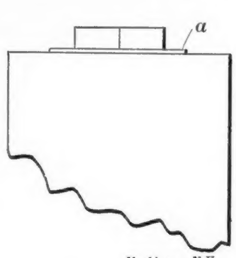


Fig. 12.

If a leak or short-circuit appears, the trouble must be located and remedied before using.

Small copper chips wedged in the micanite by the turning-tool often cause a short-circuit between segments. A careful inspection inside and out after turning, will generally disclose any such defect.

* * *

THE SLIDE RULE—POSITION OF THE DECIMAL POINT.

S. E. WOODBURY.

The following method of locating the position of the decimal point in the result of multiplication or division when using the ordinary slide rule is submitted as being very much easier to learn and use than the several methods usually presented in the instruction books.

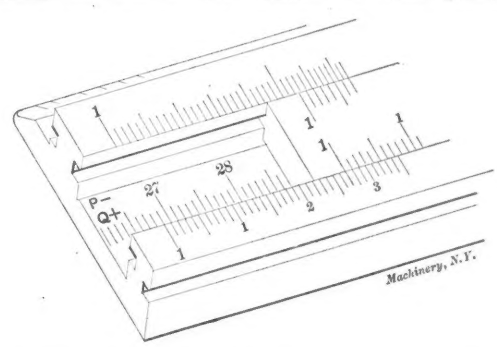
In the bottom of the groove under the slide at the left-hand end of the slide rule may be written the characters $\frac{P-}{Q+}$ (see cut). A clew to the method of using these marks is suggested by the fact that they are sometimes covered by the slide.

Assume the rule—The number of digits in a product is equal to the sum of the digits of the factors; and, the number of digits in a quotient is equal to the number of digits in the dividend less the number of digits in the divisor. This rule is true when the result is obtained with the slide projecting to the left, covering the characters $\frac{P-}{Q+}$

When the result is obtained with the slide projecting to the right, the number of digits in the result is corrected according to the indication of the characters, which are then visible. If the result is a *product* the number of digits is equal to the number obtained by the rule above given *less* one, as is indicated by *P*—. If the result is a *quotient* the number of digits is equal to the number obtained by the rule above given *plus* one, as is indicated by *Q*+. Since the correction is always one it is not included in the characters. This method is best used with the *C* and *D* scales; but can be used as well with the *A* and *B* scales after it is once understood.

If the same characters are written in the right-hand end of the groove, prefixed by *I* (signifying inverted slide), thus $I\,\frac{P-}{Q+}$ the decimal point in calculations effected with the inverted slide can be located equally as well.

Below are given examples in the four cases, more fully illustrating the use of the method. A little practice will quickly reduce the operation to a simple mental calculation of scarcely any additional effort, besides reading the results from the scales.



Note.—In dealing with decimal quantities, the number of negative digits equals the number of zeros after the decimal point.

Multiplication.		Division.	
33.2 × .515 = 17.1		13.2 ÷ 30.4 = .434	
Digits in 33.2..........	+ 2	Digits in 13.2.........	+ 2
Digits in .515..........	0	Digits in 30.4.........	+ 2
Adding gives......	+ 2	Subtracting gives.	0
P — invisible, no correction		*Q* + invisible, no correction.	
Digits in answer.......	+ 2	Digits in answer......	0
272 × .0318 = 8.65.		.0725 ÷ 36.8 = .00197.	
Digits in 272..........	+ 3	Digits in .0725........	— 1
Digits in .0318........	— 1	Digits in 36.8..........	+ 2
Adding gives......	+ 2	Subtracting gives..	— 3
P — visible correction.	— 1	*Q* + visible correction.	+ 1
Digits in answer......	+ 1	Digits in answer......	— 2

* * *

To harden and temper large fluted reamers with the appliances afforded by the average shop is trying enough by daylight, but when it must be done at night the combination of adverse conditions would ordinarily appal the average toolmaker. At night it is useless to attempt drawing the temper by the color, hence the resort to a fusible alloy to denote the proper heat for the desired temper. A toolmaker tells how he tempered a large reamer after dark for a rush job in a shipyard. After hardening the reamer, he heated it throughout until it would just melt an alloy made of equal parts of tin and lead. The temperature at which this melts corresponds closely to a straw color. Large tools should have the temper drawn at once after hardening, in order to relieve the internal strains; otherwise they are liable to crack.

TOOLMAKING.—12.

FORMING TOOLS AND MILLING MACHINE CUTTERS.

E. R. MARKHAM.

Forming tools are used when a number of pieces of exactly the same shape are to be made. They are extensively used on screw machine and similar work where it is desirable to duplicate a given shape, and are very valuable for giving the desired shape to tools of irregular contour when duplication of form is desirable. Forming tools are made either flat or circular, as seems best, or as the work to be done requires. When used for giving tools the required shape in the lathe or planer they are ordinarily made flat; if they are for backing off formed milling machine cutter teeth they are always made flat; when used on screw machines for giving a desired shape to the work they are made either flat or circular, although the latter form is more common.

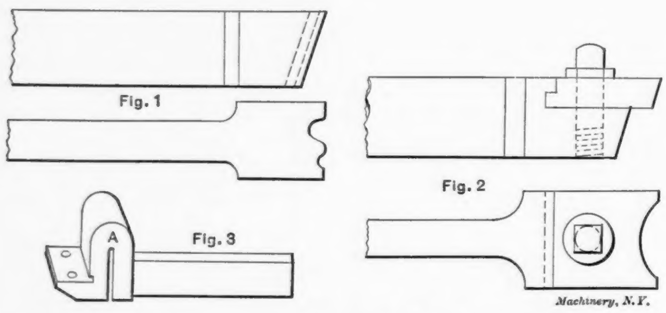


Fig. 1 Fig. 2 Fig. 3

Flat forming tools are made solid; the tool and shank may be one piece, as shown in Fig. 1, or the cutter and shank may be made separate, as shown in Fig. 2. If but one forming tool is to be made,make the solid tool; but if many tools are to be made it is much cheaper to make a shank, as shown in Fig. 2, and separable cutters for the different jobs.

To reduce the tendency to chatter when heavy cuts are taken it is sometimes advisable to make a spring holder, as shown in Fig. 3. When tools of this character are subjected to heavy cuts they yield somewhat, thus producing a smooth cut. To give the spring portion, *A*, a spring temper it is necessary to make this holder of tool steel. The blades must of course be made of tool steel and may be planed up in long strips and cut to the desired lengths. The character of the work must in a measure determine the carbon of the steel used in the blades. For the general run of work, however, steel containing 1¼ per cent. carbon will be found satisfactory; if the facilities for hardening are such that the heats can be graduated very carefully it is safe to use steel of a higher temper than that mentioned.

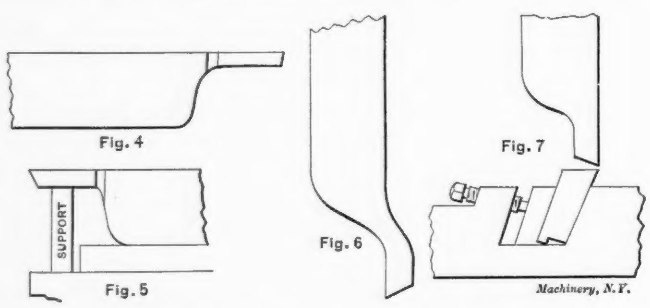


Fig. 4 Fig. 5 Fig. 6 Fig. 7

When tools of the description shown in Fig. 1 are made it is often customary to make the portion which is to receive the shape or form like that shown in Fig. 4 in order to save labor when making the form on end. This works very nicely when light cuts are taken with the tool, or if the cutting surface of the tool is not too great; but for heavy cuts the tool will chatter unless supported as shown in Fig. 5.

When very smooth surfaces are desired it will be found necessary to run the stock slower than when cutting with tools of other form. Forming tools to be used in the shaper or planer, and where a smooth surface is desirable, may be made as shown in Fig. 6. These are known as spring tools, and irregular surfaces such as occur on the faces of bending dies and similar tools may be produced with these spring tools very quickly and very smoothly. This form of tool also works nicely when applied to other than forming tools, as cut-off tools, smoothing tools for flat surfaces, etc., for use in the shaper and planer.

In the making of solid flat forming tools extreme care should be exercised in the operation of forging. Tools of this class are subjected to great strain, and in order to insure satisfactory results should never be overheated, and should be hammered in a manner that makes them the strongest possible. After forging, the tool should be carefully annealed, as this operation insures best results when the tool is hardened.

The bottom (or base), the portion on which the tool rests, should be perfectly aligned by milling, planing, or if possible, by grinding; otherwise it would not be possible to produce the same form at different seatings. The top of the tool blank should be machined flat, and parallel to the surface it rests on, after which the form should be laid out, using a templet for this purpose.

The method used in working the desired form in the face of the tool depends on circumstances. If many tools of a given form are required, or if many pieces are to be made with a tool which would necessitate grinding it several times, a method must be used that insures uniformity of shape the entire vertical length of the face of the tool. If the tool is

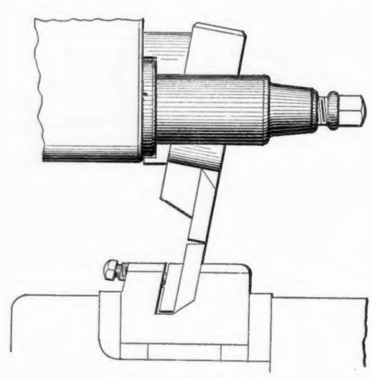


Fig. 8

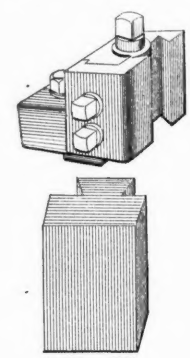


Fig. 9.

to be used but a little the desired form may be produced by filing; but as it would be almost impossible to file an irregular shape that would maintain its form the entire length of the face, each time the tool was ground, the shape of the pieces machined would change with each grinding.

The tool may be held at the desired angle in the vise of the planer, shaper, or milling machine, if the form is to be produced by machining. The usual practice is to have a fixture which holds the work at the desired angle of clearance. According to the writer's experience forming tools to be used for the general run of work should be given a clearance of

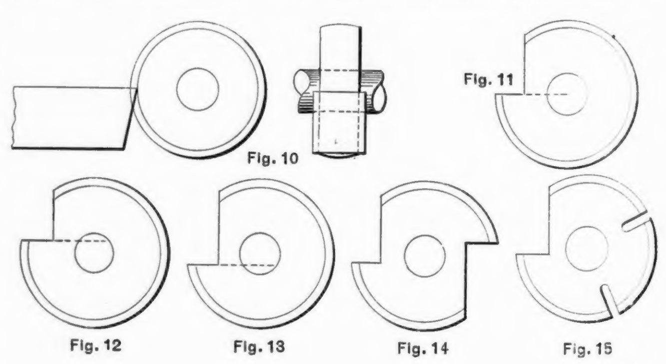


Fig. 10 Fig. 11 Fig. 12 Fig. 13 Fig. 14 Fig. 15

10 to 15 degrees, that is the included angle to the top of the tool should be from 80 to 75 degrees. However, if the tool is to be used for backing off the teeth of formed milling machine cutters, it is necessary to give a clearance of 18 to 22 degrees.

It will be apparent that tipping the tool in the vise, as described, prevents duplicating the shape of the master tool, if that is held in a vertical position in the toolpost of the

shaper or planer, as shown in Fig. 7. To overcome this difficulty the master tool may be made enough different in shape to produce the desired shape; or the tool may be held in the toolpost, or in a special holder, at the same angle as the blank, as shown in Fig. 8, and it will produce a shape corresponding very closely with its own.

When forming tools are used continually, the form shown in Fig. 9 is considered in most shops the most satisfactory. The cutters are made separable, and held in the holder at the desired angle. As the cutters are held very rigidly extremely heavy cuts can be taken without the tool slipping or chattering. This tool recommends itself where the same form is to be duplicated right along, as the cutters are very easily and

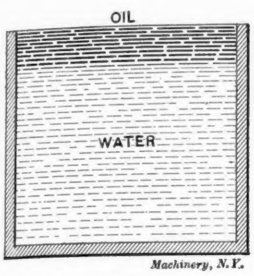


Fig. 16.

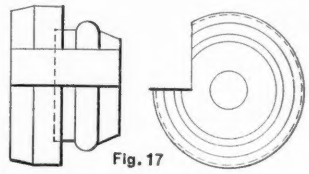


Fig. 17

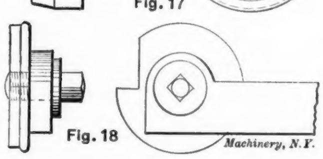


Fig. 18

cheaply produced after the master cutters have been made. The shape may be worked in the face of the tool either by milling or planing; the former method is, generally speaking, the more satisfactory.

Circular Forming Tools.

Circular forming tools are used very extensively on screw machine and similar work. They commend themselves on account of the ease with which any number of them may be produced, provided a master tool is used in producing the shape, as shown in Fig. 10. If the master tool is properly made, and does not project very far from the toolpost, it should produce a very smooth surface, provided the cutter blank is held on a short mandrel and is run extremely slow for the finishing cut. If the exact shape is not essential it may be given a very smooth finish by polishing with fine emery and oil on a soft pine block. This practice, while common, should never be resorted to when accuracy in contour is essential.

To provide a cutting edge the tool is milled as shown in Fig. 11. It is necessary to have the cutting surface radial as shown, if we desire to duplicate the exact shape of cutter. If the cutting edge is above the center, as shown in Fig. 12, the tool will not cut; if below the center, as shown in Fig. 13, it will cut very nicely but will not produce a correct shape. In many shops it is considered advisable to make the cut, as shown in Fig. 13, to insure rapid cutting, the form of the tool being somewhat different, to compensate for this. Before hardening, the name or the number of the tool is stamped on it. It is customary in some shops to mill two cutting edges, as shown in Fig. 14, in order to reduce the tendency to crack when the tool is hardened; at other times it is considered advisable to make two extra cuts, as shown in Fig. 15. However, if the tools are heated very carefully and dipped in a bath similar to that illustrated in the October number of MACHINERY (Fig. 19), the contraction is so uniform that there is little danger of cracking. It is necessary, of course, when using this bath to dip the tool so that the water issuing from the perforated pipes strikes the face of the tool. The pipe at the bottom that throws a vertical jet of water, should be closed to prevent the water being forced against one side of the tool, as this would cause unequal contraction.

If it is necessary to use an ordinary bath of water, or brine, the tool should be worked around well in the bath. When it is cooled the strains should be removed by reheating sufficiently to reduce the tendency to crack. If the form of the tool is such that it is not necessary to draw the temper it is ready for use after the cutting surface has been ground. If it is necessary to draw the temper, it may be done by heating in a kettle of oil, gaging the temperature by means of a thermometer; or the sides may be brightened and the temperature gaged by the color. Usually, however, sufficient toughness may be produced by drawing to a temperature that would not produce any temper color. In such cases it is necessary to use the heated oil and thermometer, as described. In some instances the brittleness may be reduced sufficiently by placing in a kettle of water which may be gradually heated until it boils, allowing the water, with the tool in it, to boil sufficiently long to insure the tool being uniformly heated to the temperature of the water (212 degrees F.). A method used in some shops with excellent results, consists in quenching the tool in a bath of water having a layer of oil about 1 inch on the top, as shown in Fig. 16. The heated steel passing through the oil into the water acquires a thin coating of oil, which lessens the shock incident to plunging red-hot steel into cold water.

The writer has had excellent results when hardening both flat and circular forming tools by the method previously described as "Pack hardening" (in the May issue of MACHINERY). The tools stood up nicely, and the tendency to crack was entirely eliminated; and in the case of circular forming tools which had threaded holes, the tendency to shrinking out of size was reduced to the minumum.

Circular forming tools having large and small portions adjoining, as shown in Fig. 17, are many times made of two or more pieces; this simplifies the operation of making and tools of this character can be hardened with less liability of breaking than if made in one piece. When possible the smaller portion should be recessed into the larger, as shown. This does away with the tendency of the smaller portion to crumble at the end which comes against the larger portion.

Forming tools of small diameter cut more rapidly than larger ones when the cutting edges of both are radial, as the metal below the cutting edge recedes more rapidly, thus giving a greater amount of clearance.

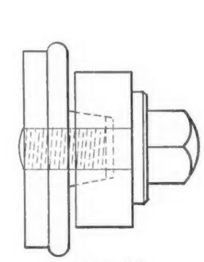


Fig. 19

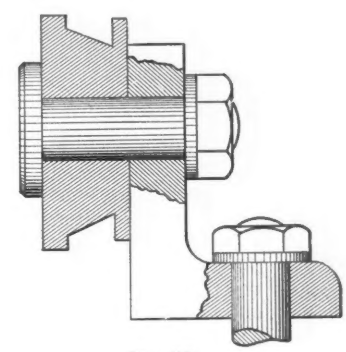


Fig. 20

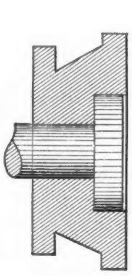


Fig. 21

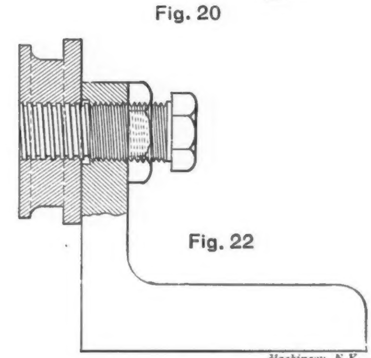


Fig. 22

Tool Holders. It is necessary to provide a holder for circular forming tools, the design depending altogether on the class of work to be done. For use in an ordinary hand screw machine the one shown in Fig. 18 answers nicely. If the work is light the flat side of the tool is drawn against the side of the holder by means of a screw. Fig. 19 shows a tool having a taper projection on one side which fits a taper hole in the holder. The holder, if made this way, should not be hardened; at least the walls of the taper hole should not be hard.

When the tool is to be used in the automatic screw machine the holder is usually of a different design than if for a hand machine. Especially is this the case when heavy work, or work which would bring a great strain on the tool, is to be

done. The more common holder is that shown in Fig. 20, and is made in the form of an angle iron. The bottom of the holder is usually provided with a tongue which fits in the slot in the tool rest. The fixture is securely fastened to the rest by means of bolts, as shown. If the head of the bolt projecting beyond the surface of tool is objectionable it may be made flush, Fig. 21. When extremely heavy cuts are to be taken the form of holder described above may not hold the tool securely, and in such cases it is often considered advisable to make a holder like that shown in Fig. 22. The tool should have a square thread in the bore, the pitch of which is 1-5 or 1-6 inch (that is 5 or 6 threads per inch) right or left hand, according to which side of the holder it is to be located on when in use, so that the tool will have a tendency to tighten when cutting. To get a fine adjustment the thread in the holder must be of finer pitch than that in the tool, and of the same hand. It is obvious that extreme care must be exercised when cutting the thread in the holder, to insure its being at right angles with the face against which the tool is to rest.

Milling Machine Cutters.

No one branch of machine shop work has made greater strides than the process of removing stock by means of rotating cutters used in connection with milling machines. The progress has been especially marked since the introduction of grinding machinery and of wheels made of abrasive materials, making it possible to leave the cutters as hard as is consistent with toughness.

The introduction of formed cutters has made practical the manufacture of intricate forms which can be ground on their cutting faces without changing their shape. The writer can remember as a boy making cutters of irregular shape which,

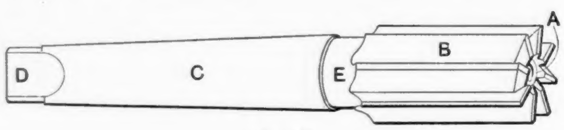


Fig. 23

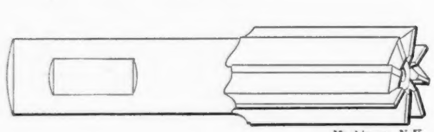

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Fig. 24

after hardening, were softened sufficiently while tempering to permit of their being sharpened when dull by scraping with a three-cornered scraper, hardened very hard. This operation could only be repeated a few times before it was necessary to anneal them and re-work to shape.

The use of formed mills makes it possible to mill intricate shapes which it was formerly necessary to produce by planing; and much more cheaply.

End Mills. This form of milling machine cutter is provided with a shank which is held in a collet or in a chuck, and in many shops this is called a shank mill. Generally speaking the shanks are made tapering, as shown in Fig. 23, and the collet has a corresponding tapered hole to receive the shank. In some cases, however, the shanks are made straight, as in Fig. 24, and then the collet has a straight hole of the size of the shank. The cutter is held in place by means of a setscrew, or the shank may be held in a chuck, although this is not a common method. The collet referred to is used to save stock, as otherwise it would be necessary to use steel sufficiently large to make a shank of the size of the hole in the milling machine spindle.

End mills are made right- and left-handed. The one shown in Fig. 23 is called a left-hand mill; a right-hand mill has its teeth cut so as to necessitate running the cutter in the opposite direction.

For the general run of work steel containing 1¼ per cent. carbon answers nicely for mills of this description. If extreme care is taken when hardening, steel containing a higher percentage of carbon may be used and will be found more satisfactory. The stock should be enough larger than the cutting portion of mill to permit turning off the decarbonized surface of the steel. When the ends are faced to length, and a chip has been turned off, to clean the surface, one end is run in the steadyrest and the center is cut as at *A*, Fig. 23. The object of recessing the end is to furnish a cavity for the cutter to enter that is used to cut the teeth on the end. It also facilitates the operation of grinding the teeth on the end.

If the mill is to have a tenon on the end, as indicated at *D*, this may be turned to size and milled, as shown. It should be a trifle (1-32 inch) thinner than the width of the center key slot in the collet. The tapered portion, *C*, is made sufficiently large to allow of grinding after the cutter is hardened, in order to insure its running true. The cutting portion, *B*, is also turned a trifle (say .01 inch) large, to provide

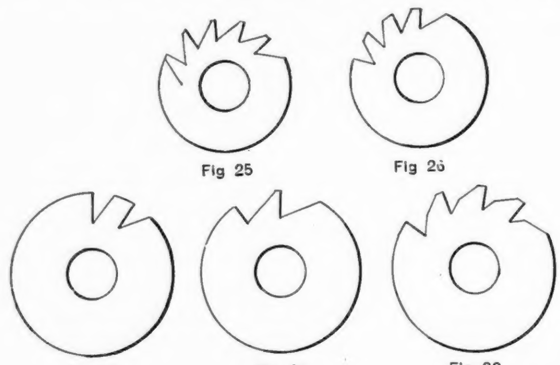
Fig 25 Fig 26

Fig 29 Fig 27 Fig. 28

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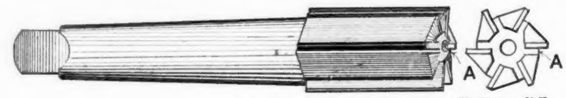
for grinding; and the portion *E* should be 1-32 inch smaller than the large end of the taper, unless specific instructions as to size are given on the drawing.

End mills have their teeth cut both straight and spiraling, according to the uses to which they are to be put. To insure a strong tooth, or one that will resist the strain incident to cutting, due regard must be paid to its shape. Not only must the tooth be strong but it must be cut deep enough to hold chips and not clog. A thin tooth, like that shown in Fig. 25, will spring into the stock when cutting, which puts an additional strain on the tooth and causes it to break. The tooth must not be too broad across the top (Fig. 26) or it will not be possible to grind it satisfactorily. Fig. 27 shows a cutter whose teeth are strong and deep enough to hold the chips and yet work in a satisfactory manner. At times it is desirable to have cutter teeth of the form shown in Fig. 28. This is done by first cutting around with an angular mill that will produce a tooth like that in Fig. 29, and then turning the index head and finishing the tooth to the shape shown in Fig. 28. This tooth answers nicely when the cutter is to be subjected to great strain, as when cutting irregular surfaces, or where it will come in contact with corners of the work.

The number of teeth to cut in an end mill cannot be stated arbitrarily; this will depend altogether on circumstances. There is a tendency in many shops to make cutters having too many teeth rather than too few.



Machinery, N.Y.

Fig. 30.

When it is necessary to cut into the surface of a piece of work with the end of the mill and then feed along, as in die work, internal cams, etc., the teeth are sharpened or given clearance, on the inside, and so are able to cut a path from the point where the mill is sunk into the work. The teeth being very coarse allow of heavy cuts. This is especially the case when cast iron is the material being machined. After cutting the teeth on the end of the mill a thin metal-splitting saw of comparatively small diameter should be run through close to the face of each tooth, making the cut shown in Fig. 30 at *A*. This cut is to permit backing off the inner edge of the tooth; which gives the mill a cutting tooth on the inside as well as on the outside, and allows it to cut away the projection made when the mill was fed into the work.

For end mills with spiral teeth it will be necessary to have

a spiral that will cause the shank of the mill to stay in the collet rather than draw it out. The subject of spiral teeth will be considered in another part of this article, under milling machine cutters with spiral teeth.

T-Slot Cutters. It is customary to provide with T-slots all machines which are to hold the work by means of both. These slots were formerly cut on a planer, with a tool like that in Fig. 31. When many slots are to be cut this is an expensive method and has been almost entirely superseded by the use of a milling cutter made especially for this pur-

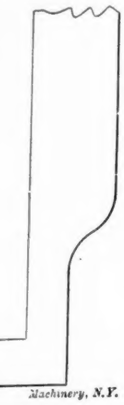


Fig. 31.

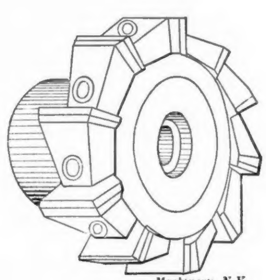


Fig. 38.

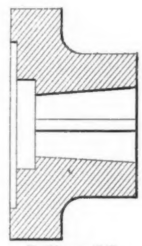


Fig. 40.

pose, and termed T-slot cutter, Fig. 32. This form of cutter is made 1-32 inch larger than its designated size, to allow for grinding; that is, a ¾-inch T-slot cutter would be ¾ inch + 1-32 inch diameter when ready for use, unless the T-slot is to be cut to given dimensions. Teeth must be provided on the sides of this form of mill, as shown in Fig. 32.

It is advisable to harden mills of this description the entire length of the necked portion marked *B*, especially if the neck is of small diameter. Draw the neck to a blue color when tempering, and the cutting portion to a straw color. The teeth of T-slot cutters should be coarse and of a form that insures the greatest strength possible, allowing of course sufficient space between teeth to accommodate chips.

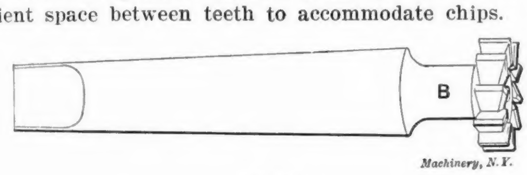


Fig. 32.

Fly Cutters. This is the simplest form of milling machine cutter, and is often used when but one piece, or a limited number of pieces of irregular shape, is to be produced. It recommends itself for experimental and similar work, on account of cheapness and the ease with which it can be made. As shown in Fig. 33 the cutter, which is single, is held in a holder known as a "fly cutter arbor." This cutter is given its shape and clearance by several methods. If the shape is not very intricate it may be produced by filing. To make a fly cutter from a forming tool the square piece of steel for the cutter is held in the fly cutter arbor and the shape produced by the forming tool. To get the necessary clearance the face

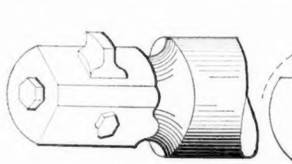


Fig. 33

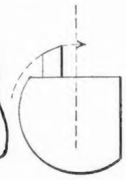


Fig. 34

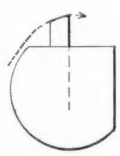


Fig. 35

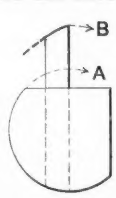


Fig. 36

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of the tool is set somewhat back of the center, as shown in Fig. 34. This is readily done as the stock used for the cutter need not be as large as the hole in the arbor. It is held in position by pieces of steel used as blocks, and is then securely fastened by setscrews provided with the arbor. After being hardened the cutter is placed in the holder so that the face is radial, Fig. 35, and it will be found to have the necessary clearance.

A commonly used method for getting the desired clearance consists in placing the face of the stock to be used for the cutter radial but locating the outside as near the arbor as is practical, as shown by dotted lines *A*, Fig. 36. After forming and hardening it is set to cut in the position marked *B*, and it will be found to have the necessary clearance.

While fly cutters are very useful for certain purposes they are seldom employed where many pieces are to be machined. Having but one cutting tooth they necessarily cut very slowly.

Face Milling Cutters. This form of cutter is used quite extensively on certain classes of work and is especially valuable for use on surfaces too large to be machined with the ordinary type of cutter held on a milling machine arbor. For work to be milled with a cutter held on an arbor, as shown at *A*, Fig. 37, it is necessary to use a cutter whose diameter is twice the size of the surface being machined, plus the diameter of the arbor. When a face mill is used, as at *B*, the diameter of the cutter need only exceed the width of surface being milled by a trifle.

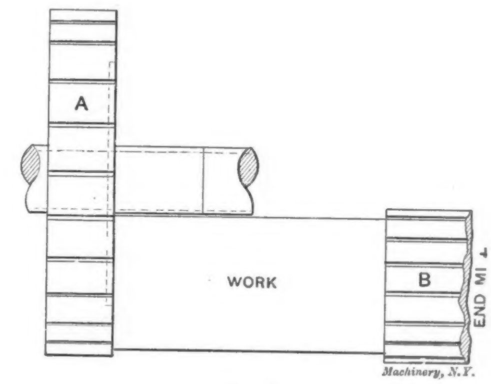


Fig. 37.

For large work mills having inserted teeth are used, Fig. 38. The body of the mill is made of machinery steel, or cast iron, and the teeth of tool steel, hardened, or else of high-speed steel. When the machine employed is sufficiently strong to resist the extra strain incident to high speeds, use high-speed steel in making the teeth, for the amount of work produced per machine may thus be more than doubled. The advantages claimed for cutters having inserted teeth are that while the cost of making the first cutters may not be any less than for a solid one, the teeth may be renewed when worn out, at a comparatively low cost. Then again it is not, generally speaking, advisable to harden milling machine cutters above 6 inches in diameter in a shop provided with only ordinary facilities for doing work of this character.

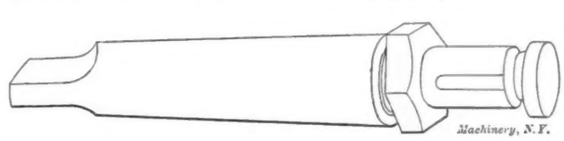


Fig. 39.

It is considered best practice in most shops to make cutters of this description with taper holes. The arbor, of course, has a corresponding taper and is provided with a key which prevents the cutter turning on the arbor. The arbor is provided with a screw which draws the cutter onto the taper, as will be seen in Fig. 39, while Fig. 40 represents a sectional view of a cutter, showing it recessed to receive the screw head.

If the cut is to extend more than ¾ inch on the face of the mill, the teeth are made spiral; but if the cut does not exceed this width the teeth are made straight, mills with straight teeth being less costly.

The various methods used to hold the teeth in place will be considered in the next article, which will deal with milling machine cutters in general.

* * *

The increase in mechanical efficiency of engines with forced lubrication has been clearly shown by recent engines built by the B. F. Sturtevant Co. at Hyde Park, Mass., and fitted with a forced pump lubricating system. An increase of from 8 to 10 per cent is shown, and with their latest type of vertical single engines a mechanical efficiency averaging 94 per cent.

THE DEVELOPMENT AND USE OF HIGH-SPEED TOOLS.*

The high-speed steels of the present day are combinations of iron and carbon with: (1) Tungsten and chromium, (2) Molybdenum and chromium, (3) Tungsten, molybdenum and chromium.

Influence of Carbon.—A number of tool steels were made by the Armstrong Whitworth Co. with the carbon percentage varying from 0.4 per cent to 2.2 per cent, and the method of hardening was to heat the steel to the highest possible temperature without destroying the cutting edge, and then rapidly cooling in a strong air blast. By this simple method of hardening it was found that the greatest cutting efficiency is obtained where the carbon ranges from 0.4 per cent to 0.9 per cent, and such steels are comparatively tough. Higher percentages are not desirable because great difficulty is experienced in forging the steels, and the tools are inferior. With increasing carbon contents the steel is also very brittle, and has a tendency to break with unequal and intermittent cutting.

Influence of Chromium.—Having thus found the best carbon content to range from 0.4 per cent to 0.9 per cent, the next experiments were made to ascertain the influence of chromium varying from 1.0 per cent to 6.0 per cent. Steels containing a low percentage are very tough, and perform excellent work on the softer varieties of steel and cast-iron, but when tried on harder materials the results obtained were not so efficient. With an increased content of chromium the nature of the steel becomes much harder, and greater cutting efficiency is obtained on hard meterials. It was observed that with an increase of chromium there must be a decrease in carbon to obtain the best results for such percentage of chromium.

Mention may here be made of an interesting experiment to ascertain what effect would be produced in a rapid steel by substituting vanadium for chromium. The amount of vanadium present was 2.0 per cent. The steel readily forged, worked very tough, and was hardened by heating to a white heat and cooling in an air blast. This tool when tried on medium steel stood well, but not better than the steel with the much cheaper element of chromium in it.

Influence of Tungsten.—This important element is contained in by far the greater number of the present high-speed steels in use. A number of experiments were made with the tungsten content ranging from 9.0 per cent to 27.0 per cent. From 9.0 per cent to 16.0 per cent the nature of the steel becomes very brittle, but at the same time the cutting efficiency is greatly increased, and about 16.0 per cent appeared to be the limit, as no better results were obtained by increasing the tungsten beyond this figure. Between 18.0 per cent and 27.0 per cent it was found that the nature of the steel altered somewhat, and instead of being brittle, it became softer and tougher, and whilst such tools have the property of cutting very cleanly, they do not stand up so well.

Influence of Molybdenum.—The influence of this element at the present time is under investigation, and our experiments with it have so far produced excellent results, and it was found that where a large percentage of tungsten is necessary to make a good rapid steel, a considerably less percentage of molybdenum will suffice. A peculiarity of these molybdenum steels is that in order to obtain the greatest efficiency they do not require such a high temperature in hardening as do the tungsten steels, and if the temperature is increased above 1,800 degrees F. the tools are inferior, and the life shortened.

Influence of Tungsten with Molybdenum.—It was found that the presence of from 0.5 per cent to 3.0 per cent molybdenum in a high tungsten steel slightly increased the cutting efficiency, but the advantage gained is altogether out of proportion to the cost of the added molybdenum.

Influence of Silicon.—A number of rapid steels were made with silicon content varying from a trace up to 4.0 per cent. Silicon sensibly hardens such steels, and the cutting efficiency on hard materials is increased by additions up to 3.0 per cent. By increasing the silicon above 3.0 per cent, however, the cutting efficiency begins to decline. Various experiments were made with other metals as alloys, but the results obtained were not sufficiently good by comparison with the above to call for comment.

An analysis of one of the best qualities of rapid steels produced by the author's firm (Armstrong, Whitworth Co.) is as follows: "A.W." Steel.—Carbon, 0.55 per cent; Chromium, 3.5 per cent; Tungsten, 13.5 per cent.

What may be said to determine a high-speed steel, as compared to an ordinary tool steel, is its capability of withstanding the higher temperatures produced by the greatly increased friction between the tool and the work due to the rapid cutting. An ordinary carbon steel containing, say, 1.20 per cent carbon when heated slightly above the critical point and rapidly cooled by quenching in water becomes intensely hard. Such a steel gradually loses this intense hardness as the temperature of friction reaches, say, 500 degrees F. The lower the temperature is maintained the longer will be the life of the tool, so that the cutting speed is very limited. With rapid cutting steels the temperature of friction may be greatly extended, even up to 1,100 degrees F. to 1,200 degrees F., and it has been proved by experience that the higher the temperature for hardening is raised above the critical point and then rapidly cooled, the higher will be the temperature of friction that the tool can withstand before sensibly losing its hardness. The high degree of heating (almost to melting point, in fact) which is necessary for hardening high-speed

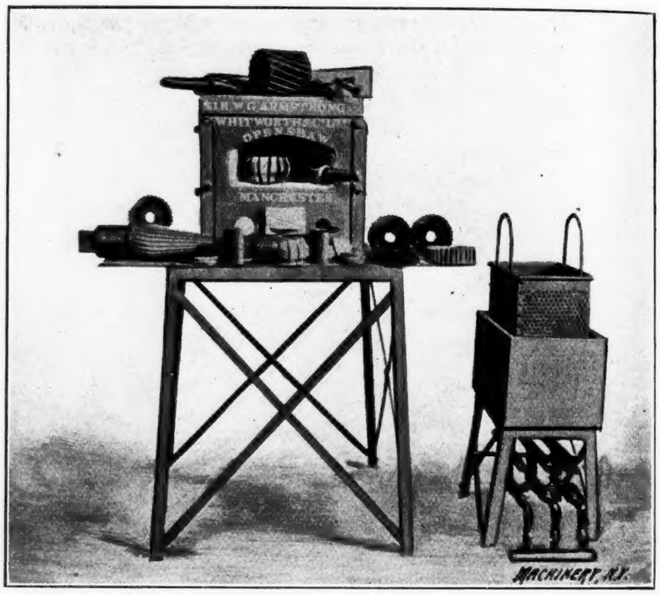


Fig. 1. Muffle Furnace for Hardening Milling Cutters made of High-speed Steel; also Tank and Dipping Cage for Tempering them in Oil.

steel forms an interesting study in thermal treatment and is indeed a curious paradox, quite inverting all theory and practice previously existing. In the case of hardening ordinary carbon steels very rapid cooling is absolutely necessary, but with high-speed steels the rate of cooling may take a considerably longer period, the intensity of hardness being increased with the quicker rate of cooling.

Heat Treatment of High-speed Steel.

Turning now to some points in the heat treatment of high-speed steel, one of the most important is the process of thoroughly annealing it after working into bars. Accurate annealing is of much value in bringing the steel into a state of molecular uniformity, thereby removing internal strains that may have arisen, due to casting and tilting, and at the same time annealing renders the steel sufficiently soft to enable it to be machined into any desired form for turning tools, milling cutters, drills, taps, screwing dies, etc. The annealing of high-speed steel is best carried out in muffle furnaces designed for heating by radiation only, a temperature of 1,400 deg. F. being maintained from twelve to eighteen hours according to the section of the bars of steel dealt with. Further advantage also results from careful annealing by minimizing risks of cracking when the steel has to be reheated for hardening. In cases of intricately-shaped milling tools having sharp square bottom recesses, fine edges, or delicate projections, and on which un-

* Abstract of paper read by Mr. J. M. Gledhill before the Iron and Steel Institute, October, 1904.

equal expansion and contraction are liable to operate suddenly, annealing has a very beneficial effect toward reducing cracking to a minimum. Increased ductility is also imparted by annealing, and this is especially requisite in tools that have to encounter sudden shocks due to intermittent cutting, such as planing and slotting tools, or others suddenly meeting projections or irregularities on the work operated on.

In preparing high-speed steel ready for use the process may be divided principally into three stages: forging, hardening, and grinding. It is, of course, very desirable that high-speed steel should be capable of attaining its maximum efficiency and yet only require treatment of the simplest kind, so that an

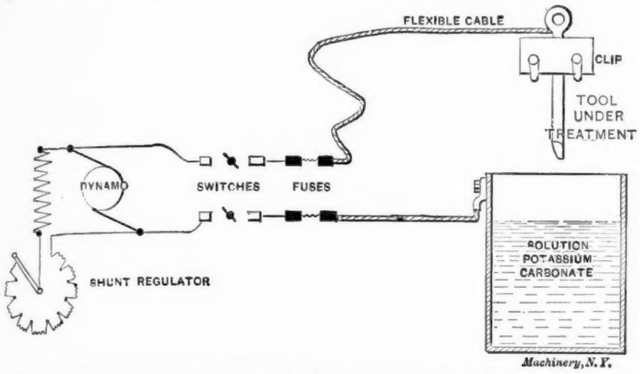


Fig. 2. Apparatus for Hardening Tools Electrically in a Bath of Potassium Carbonate.

ordinarily skilled workman may easily deal with it, otherwise the preparation of tools becomes an expensive and costly matter, and materially reduces the advantages resulting from its use. Fortunately, the treatment of the rapid steel produced by the author's firm is of the simplest; simpler in fact than ordinary carbon steels or the old self-hardening steels. Great care had to be exercised in the heating of the latter steels, for if either were heated above a blood-red heat, say 1,600 degrees F., the danger of impairing their efficiency by burning was considerable; whereas with the high-speed steel, heating may be carried to a much higher temperature, even up to melting point, it being practically impossible to injure it by burning. The steel may be raised to a yellow heat for forging, say 1,850 degrees F., at which temperature it is soft and easily worked into any desired form, the forging proceeding until the temperature lowers to a good red heat, say 1,500 degrees F., when work on it should cease and the steel be reheated.

In heating a bar of high-speed steel preparatory to forging (which heating is best done in a clear coke fire) it is essential that the bar be heated thoroughly and uniformly, so as to ensure that the heat has penetrated to the center of the bar, for if the bar be not uniformly heated, leaving the center comparatively cold and stiff, while the outside is hot, the steel will not draw or spread out equally, and cracking will probably result. A wise rule in heating is to "hasten slowly."

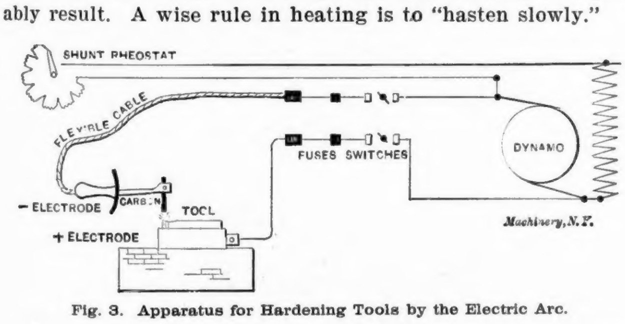


Fig. 3. Apparatus for Hardening Tools by the Electric Arc.

It is not advisable to break pieces from the bar while cold, the effect of so doing tending to induce fine end cracks to develop which ultimately may extend and give trouble; but the pieces should be cut off while the bar is hot, then be reheated as before and forged to the shape required, after which the tool should be laid in a dry place until cold.

The temperature for hardening high-speed steel varies somewhat according to the class of tool being dealt with. When hardening turning, planing, or slotting tools, and others of similar class, the point or nose of tool only should be gradually raised to a white melting heat, though not necessarily melted, but even should the point of the tool become to a greater or less extent fused or melted no harm is done. The tool should then be immediately placed in an air blast and cooled down, after which it only requires grinding and is then ready for use. Another method which may be described of preparing the tools is as follows: Forge the tools as before, and when quite cold grind to shape on a *dry* stone or *dry* emery wheel, an operation which may be done with the tool fixed in a rest and fed against the stone or emery wheel by a screw, no harm resulting from any heat developed at this stage. The tool then requires heating to a white heat, but just short of melting, and afterward completely cooling in the air blast. This method of first roughly grinding to shape also lends itself to cooling the tools in oil, which is specially efficient where the retention of a sharp edge is a desideratum, as in finishing tools, capstans and automatic lathe tools, brass-workers' tools, etc. In hardening where oil cooling is used the tools should be first raised to a white heat, but without melting, and then cooled down either by air blast or in the open to a bright red heat, say 1,700 degrees F., when they should be instantly plunged into a bath of rape or whale oil, or a mixture of both.

Referring to the question of grinding tools, nothing has yet been found so good for high-speed steels as the wet sandstone, and the tools ground thereon by hand pressure, but where it is desired to use emery wheels it is better to roughly grind the tools to shape on a dry emery wheel or dry stone *before* hardening. By so doing the tools require but little grinding after hardening, and only slight frictional heating occurs, but not sufficient to draw the temper in any way, and thus their cutting efficiency is not impaired. When the tools are ground on a wet emery wheel and undue pressure is applied, the heat generated by the great friction between the tool and the emery wheel causes the steel to become hot, and water playing on the steel while in this heated condition tends to produce cracking.

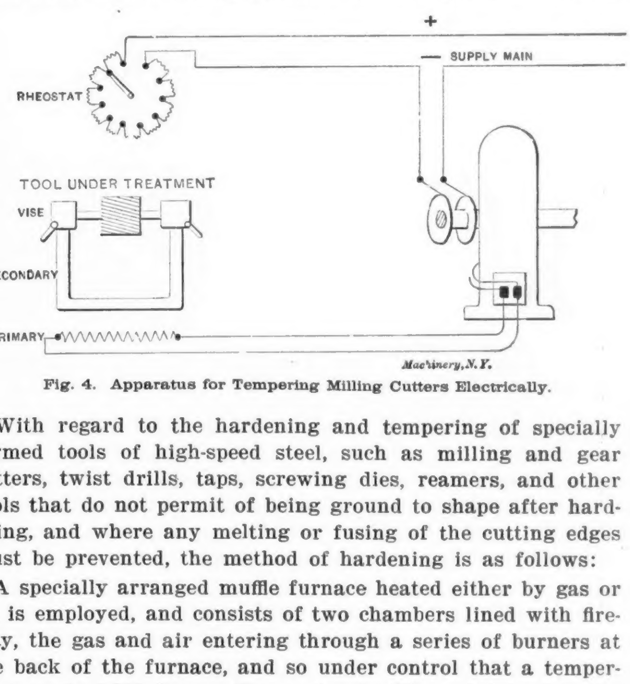


Fig. 4. Apparatus for Tempering Milling Cutters Electrically.

With regard to the hardening and tempering of specially formed tools of high-speed steel, such as milling and gear cutters, twist drills, taps, screwing dies, reamers, and other tools that do not permit of being ground to shape after hardening, and where any melting or fusing of the cutting edges must be prevented, the method of hardening is as follows:

A specially arranged muffle furnace heated either by gas or oil is employed, and consists of two chambers lined with fire-clay, the gas and air entering through a series of burners at the back of the furnace, and so under control that a temperature up to 2,200 degrees F. may be steadily maintained in the lower chamber, while the upper chamber is kept at a much lower temperature. Before placing the cutters in the furnace it is advisable to fill up the hole and keyways with common fire-clay to protect them. The cutters are first placed upon the top of the furnace until they are warmed through, after which they are placed in the upper chamber, Fig. 1, and thoroughly and uniformly heated to a temperature of about 1,500 degrees F., or, say, a medium red heat, when they are transferred into the lower chamber and allowed to remain therein until the cutter attains the same heat as the furnace itself, viz., about 2,200 degrees F. and the cutting edges become a bright yellow heat, having an appearance of a glazed or greasy surface. The cutter should then be withdrawn while the edges are sharp and uninjured, and revolved before an air blast until the red heat has passed away, and then while the cutter is still warm —that is, *just* permitting of its being handled—it should be plunged into a bath of tallow at about 200 deg. F. and the

temperature of the tallow bath then raised to about 520 degrees F., on the attainment of which the cutter should be immediately withdrawn and plunged in cold oil.

Of course there are various other ways of tempering, a good method being by means of a specially arranged gas-and-air stove into which the articles to be tempered are placed, and the

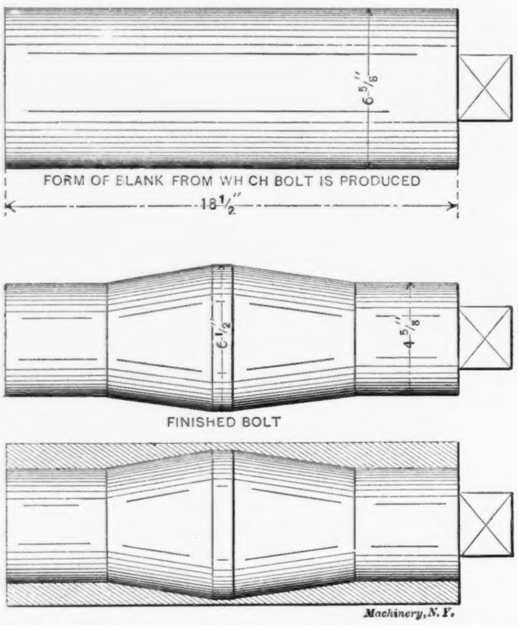


Fig. 5. Showing Stock and Finished Armor Bolts Turned at a Cutting Speed of 160 feet per minute. Mean Depth of Cut, 3-4 inch; Traverse, 1-32 inch. Reduction in Weight, 62 pounds. Forty of these Bolts were Turned in ten hours with "A. W." Steel.

stove then heated up to a temperature of from 500 degrees F. to 600 degrees F., when the gas is shut off and the furnace with its contents allowed to slowly cool down.

Another method of heating tools is by electrical means, by which very regular and rapid heating is obtained, and where electric current is available, the system of electric heating is quick, reliable, and economical. A brief description of this kind of heating may be of interest. One method adopted of electrically heating the points of tools, and the arrangement of apparatus is shown in Fig. 2. It consists of a cast-iron tank, of suitable dimensions, containing a strong solution of potassium carbonate together with a dynamo, the positive cable from which is connected to the metal clip holding the tool to be heated, while the negative cable is connected direct on the tank. The tool to be hardened is held in a suitable clip to ensure good contact. Proceeding to harden the tool the action is as follows:

The current is first switched on, and then the tool is gently lowered into the solution to such a depth as is required to harden it. The act of dipping the tool into the alkaline solution completes the electric circuit and at once sets up intense heat on the immersed part. When it is seen that the tool is sufficiently heated the current is instantly switched off, and the solution then serves to rapidly chill and harden the point of the tool, so that no air blast is necessary.

Another method of heating the point of tools is by means of the electric arc, the heating effect of which is also very rapid in its action. The general arrangement and form of the apparatus here employed being as illustrated in Fig. 3.

The tool under treatment and the positive electrode are placed on a bed of non-conducting and non-combustible material and the arc started gradually at a low voltage and steadily increased as required, by controlling the shunt rheostat, care being taken not to obtain too great a heat and so fuse the end of the tool. The source of power in this case is a motor generator consisting of a continuous-current shunt-wound motor at 220 volts, coupled to a continuous-current shunt-wound dynamo at from 50 to 150 volts. Arcs from 10 to 1,000 amperes are then easily produced and simply and safely controlled by means of the shunt rheostat.

Tempering.—Electricity is also a very efficient and accurate means of tempering such forms of tools as milling, gear, hobbing and other similar cutters, also large hollow taps, hollow reamers, and all other hollow tools made of high-speed steel, where it is required to have the outside or cutting portion hard, and the interior soft and tenacious, so as to be in the best condition to resist the great stresses put upon the tool by the resistance of the metal being cut, and which stresses tend to cause disruption of the cutter if the hardening extends too deep. By means of the apparatus illustrated in Fig. 4 this tempering or softening of the interior can be perfectly and quickly effected, thus bringing the cutter into the best possible condition to perform rapid and heavy work.

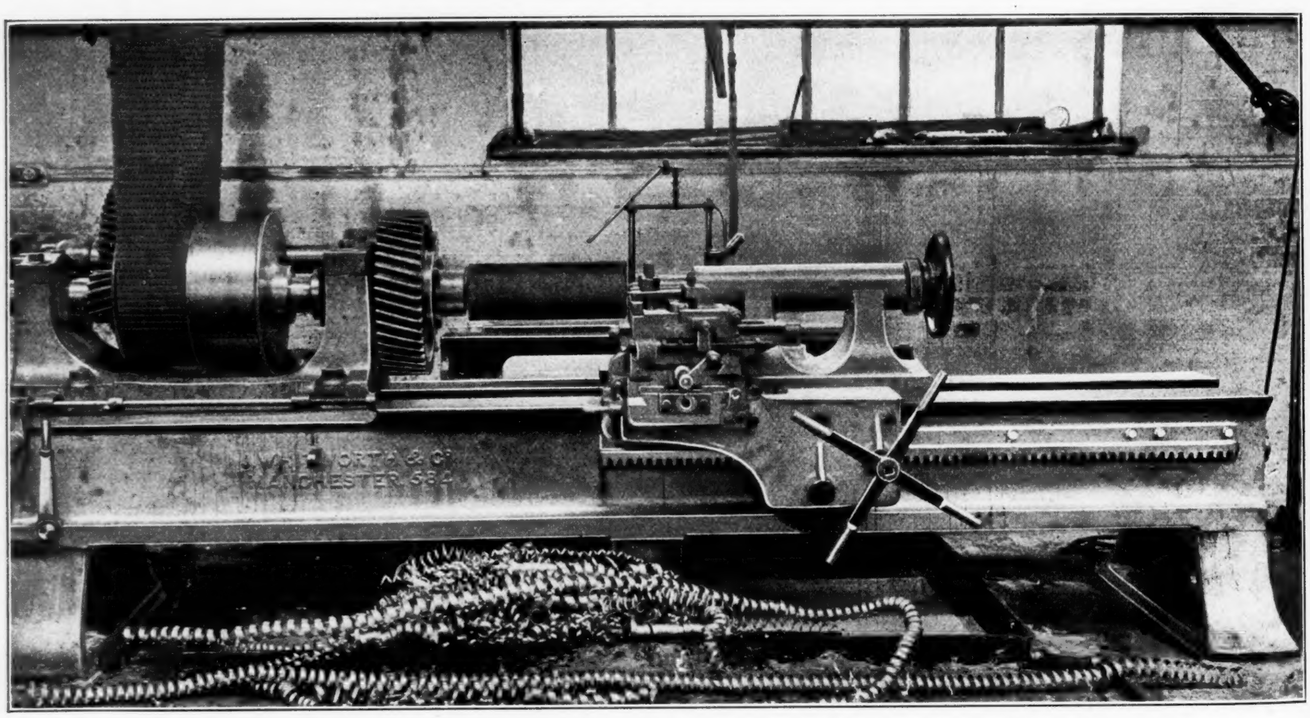


Fig. 6. Lathe used for Turning Armor Bolts. Removed 2,480 pounds of Steel Chips in ten hours.

Tempering of hollow cutters, etc., is sometimes carried out by the insertion of a heated rod within the cutter and so drawing the temper, but this is not entirely satisfactory, or scientific, and is liable to induce cracking by too sudden heat application, and further because of the difficulty of maintaining the necessary heat and temperature required, and afterward gradually lowering the heat until the proper degree of temper has been obtained. In electrical tempering these difficulties

are overcome, as the rod is placed inside the cutter quite cold, and the electric current gradually and steadily heats up the rod until the correct temperature is reached. Then it can be held at such temperature as long as is necessary, and the current can be gradually reduced until the articles operated on are cold again, and consequently the risk of cracking by too sudden expansion and contraction is reduced very greatly. The apparatus used is very simple, as will be seen by reference to Fig. 4. It consists of a continuous-current shunt-wound

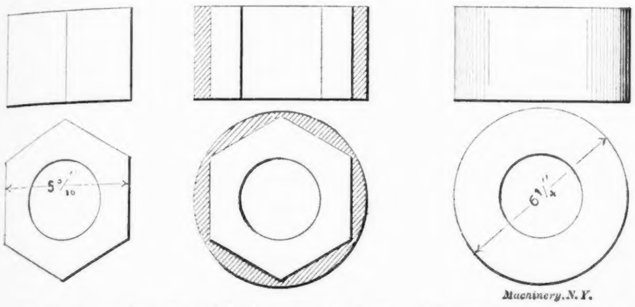


Fig. 7. Examples of Rapid Work with High-speed Milling Cutters. Speed of Cutter, 150 feet per minute; Maximum Depth of Cut, 1 1-2 inches; Reduction in Weight, 7 1-2 pounds; 90 Sleeves produced in ten hours. Total Weight of Metal removed, 675 pounds.

motor directly coupled to a single-phase alternating-current dynamo of the revolving field type giving 100 amperes at 350 volts, 50 cycles per second, the exciting current being taken from the works supply main. The power from the alternator is by means of a stepdown transformer, reduced to current at a pressure of 2 volts, the secondary coil of the transformer consisting of a single turn of copper of heavy cross-section, the extremities of which are attached to heavy copper bars carrying the connecting vises holding the mandrel upon which the cutter to be tempered is placed. The secondary induced current, therefore, passes through a single turn coil, through the copper bars and vises and mandrel. Although the resistance of the complete circuit is very low, still, owing to the comparatively high specific resistance of the iron mandrel, the thermal effect of the current is used up in heating the mandrel which gradually attains the required temperature, slowly imparting its heat to the tool under treatment until the shade of the oxide on the tool satisfies the operator. The method

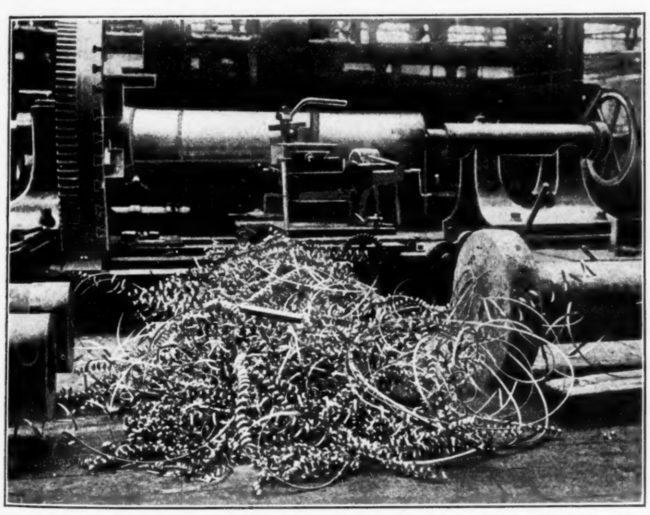


Fig. 8. Chips and Shavings produced in 45 minutes' work, Cutting Speed 150 feet per minute; Depth of Cut, 3-16 inch; Traverse, 1-16 inch.

adopted to regulate the heat of the mandrel is by varying the excitation current of the alternator by means of the rheostat. An extremely fine variation and perfect heat control is easily possible by this arrangement.

Some Results of the Use of High-Speed Steel.

It is sometimes contended that on the whole not much advantage or economy results from using high-speed steel, but it is easy to prove very greatly to the contrary. That great economy is effected is beyond all doubt, from whichever point of view the question is looked at; for it is not only rapidity of cutting that counts, but the output of machines is correspondingly increased, so that a greater production is obtained from a given installation than was possible when cutting at low speeds with the old tool steel, and the work is naturally produced at a correspondingly lower cost, and of course it follows from this that in laying down new plant and machines the introduction and use of high-speed steel would have considerable influence in reducing expenditure on capital

Fig. 9 Making Hexagon Nuts from Rolled Bars with Cutters "A. W." High-speed Steel. Ninety Nuts are produced in a day of ten hours.

account. It has also been proved that high-speed cutting is economical from a mechanical standpoint and that a given horse power will remove a greater quantity of metal at a high speed than at a low speed, for although more power is naturally required to take off metal at a high than at a low speed (by reason of the increased work done) the increase of that power is by no means in proportion to the large extra amount of work done by the high-speed cutting, for the frictional and other losses do not increase in anything like the same ratio as a high-cutting speed is to a low-cutting speed. A brief example of this may be given in which the power absorbed in the lathe was accurately measured, electrically.

Cutting on hard steel, with 3-16 inch depth of cut, 1-16 inch feed and speed of cutting 17 feet per minute, a power of 5.16 horse power was absorbed, and increasing the cutting speed to 42 feet per minute, the depth of cut and feed being the same, there was a saving in power of 19 per cent for the work being done. Another experiment with depth of cut ⅜ inch and tra-

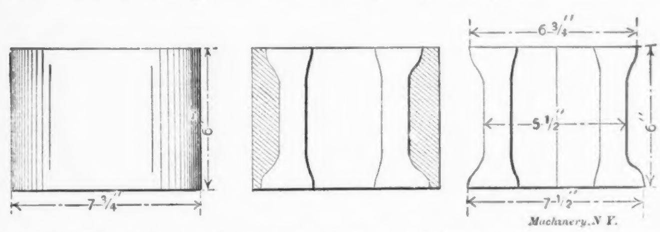


Fig. 10. Sleeves of Armor Bolts. Cutting Speed, 160 feet per minute; Maximum Depth of Cut, 1 1-8 inch; Traverse, 1-32 inch; 60 Sleeves in ten hours.

verse 1-16 inch compared with 1-16 inch traverse and 3-16 inch depth of cut, showed a saving in power of as much as 28 per cent, and still proceeding with a view of increasing the weight of metal removed in a given time the feed was doubled (other conditions being the same) and a still further saving of power resulted. In a word, as in the majority of things, so it is with rapid cutting, the more quickly work can be produced the cheaper the cost of production will be.

Again as regards economy there is not only a saving effected on the actual machine work, but since the advent of high-speed cutting it is now possible, in many instances, to produce finished articles from plain rolled bars, instead of following the old practice of first making expensive forgings and afterward finishing them in the machine. By this practice not only is the entire cost of forging abolished, but the machining on the rolled bar can be carried out much quicker and cheaper in suitably arranged machines, quicker even than the machining of a forging can be done.

A remarkable sample of the gain resulting from the use of

high-speed cutting from rolled bars is illustrated in Fig. 5, the articles in this case being securing bolts, made by the author's firm, for armor plates. Formerly where forgings were first made and then machined with ordinary self-hardening steel, a production of eight bolts per day of ten hours was usual. With the introduction of rapid-cutting steel, forty similar bolts from the rolled bar are now produced in the same time, thus giving an advantage of five to one in favor of quick cutting, and also in addition abolishing the cost of first rough forging the bolt to form; in fact, the cost of forging one bolt alone amounted to more than the present cost of producing to required form twelve such bolts by high-speed machining. The cutting speed at which these bolts are turned is 160 feet per minute, the depth of cut and feed being respectively ¾ inch and 1-32 inch, the weight of metal removed from each bolt being 62 pounds, or 2,480 pounds in a day of ten hours, the tool being only ground once during such period of work, and from such an example as this it will be at once apparent what an enormous saving in plant and costs results. On the same principle the sleeves (see Fig. 10) for these bolts are produced from bars, sixty being made in one day of ten hours, this being even a greater saving on the old system than the bolt example shows.

An illustration of the lathe on which this work is done is also shown in Fig. 6. It is a 12-inch lathe of special design and strength for rapid and heavy cutting, and has a link driving belt of 7½ inches wide, running at a very high velocity and driven by its own motor, so that the power absorbed can always be observed whether the lathe is running idle or cutting.

Equally remarkable results are obtained by operating on stock bars with high-speed milling cutters, and one example, amongst many, may be cited, which is shown in Fig. 7. Here hexagon nuts for 3⅜ inches diameter bolts are made from rolled bars, the cutting speed of milling being 150 feet per minute, giving a production of ninety nuts per day, against thirty formerly. More than ninety nuts could have been produced had the machine been more powerful.

Many other examples of rapid work in planing, milling, drilling, and turning in the Armstrong Whitworth Co.'s and other shops were given by the author.

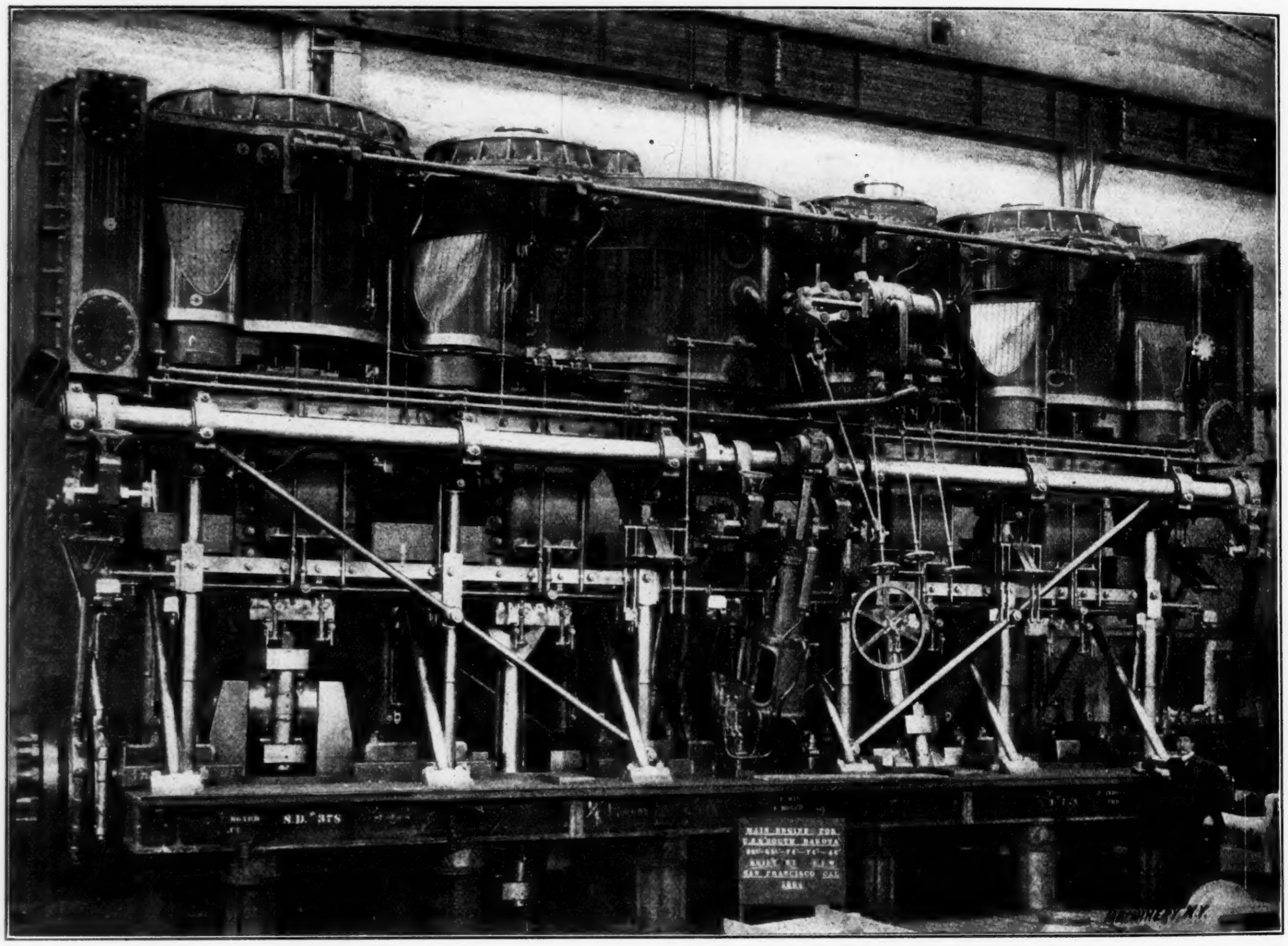
* * *

ENGINES FOR U. S. ARMORED CRUISERS NOS. 6 AND 9, THE CALIFORNIA AND SOUTH DAKOTA.

EARL N. PERCY.

The accompanying half-tone shows an interesting and in some ways wonderful type of steam engine. It is a naval engine of nearly 13,000 indicated horse power, each boat having two, which on the Colorado aggregated 25,000 horse power.

It is a four-cylinder triple-expansion engine with one high-pressure, one intermediate and two low-pressure cylinders. The cylinders are 38½ inches diameter, high-pressure, 63½ inches, diameter of intermediate pressure and diameter of each low-pressure, 74 inches by 48 inches common stroke. The low-pressure cylinders are on each end, and the high-pressure cylinder is forward. These engines are rated at 11,500 horse power each at 120 revolutions, with 250 pounds steam pressure.



One of the Main Engines for the United States Armored Cruiser South Dakota—13,000 I. H. P.

The frame is built entirely of nickel steel rods, to secure lightness, and the bed is of cast steel. Each cylinder is fitted with a liner fastened at the bottom, and provided with a gland on top to allow for expansion. Between each liner and casing is a steam jacket, which is supplied direct from the boilers. The pistons use cast iron snap rings, set out by springs. Watson's packing is used exclusively on all rods. The slide valves are balanced for steam pressure and for weight. The reversing engine is oscillating, being swung on trunnions, thus doing away with crosshead and connecting rod. The main throttle is worked by the large wheel. The auxiliary throttle bypasses the main throttle, and is used for warming up, and operating at slow speeds. The other valves are passovers for warming up, and starting engines. The numerous levers, aside from the reverse, are for the drain cocks.

Separate steam, twin beam airpumps are used. The condenser for each engine has about 14,400 square feet of cooling surface. There are two main exhaust pipes for each engine, four in all, each 27 inches diameter. The main steam pipe for each engine is 13 inches diameter. The condenser takes a 21-inch stream of circulating water thrown by a 10 and 18 x 10-inch compound engine running 200 revolutions per minute. The centrifugal pump runner is 38 inches diameter. Each condenser has 6,280 tubes 5/8 inch diameter, 14 feet long. The shells are 7 feet 5 inches diameter, and the tubes are spaced 15-16 inches apart.

Steam is supplied by sixteen Babcock & Wilcox marine water tube boilers having an aggregate heating surface of 70,944 square feet, and grate surface of 1,600 square feet. Each boiler has a Howden hot air forced draft system, with its own heater and blower engine, and is entirely independent of the rest of the plant except for the steam connections.

The connecting-rods are only 96 inches long, giving a very short connection, with excessive angularity, but making the engine low and compact. The guides are of the slipper type, being on one side only, with overlapping lips. As the engines turn outboard when going ahead, they are operated from the back. While the view is somewhat obstructed, it gives great tactical advantages.

The entire engine is supplied with water service to cool bearings and guides. The shafts and crankpins are hollow, and this space is utilized to force oil into the crank bearings. The eccentrics are oiled by telescope tubes and all other parts by a system of forced drips. All parts can be reached directly if any of the automatic gear fails.

These vessels are of 13,400 tons displacement, and must make upward of 22 knots per hour, the Colorado averaging 22¼ knots on her trial trip. They are 502 feet long, 66 feet 6½ inches wide and draw about 25 feet of water. They are armored and have two turrets equipped with 8-inch guns. Besides the four 8-inch breech-loading rifles in the turrets, there will be fourteen 6-inch rapid-fire guns, eighteen 3-inch rapid-fire guns, twelve 3-pounder semi-automatic guns, four 1-pounder heavy semi-automatic guns, two 3-inch field pieces, two machine guns, 0.30 inch caliber, and six automatic guns 0.30 inch caliber.

All wood on these boats is fireproofed. The ship's equipment includes a laundry equipped with one washer, one hydro-extractor, one mangle, two sets of tubs, one tank, dryer, etc., all driven by an electric motor.

* * *

VERTICAL BOILERS IN POWER PLANTS.

The large power plants which have recently been erected in the more populous cities for street railway work, etc., have come to follow certain standard lines of construction. This is especially so in regard to the boiler plant, where the approved arrangement is a double row of water-tube boilers with a center passage between them; above the boilers the economizers; and above all and directly under the roof of the structure, the coal bins, from which the coal descends to the automatic stokers. In a letter to the *Engineering Record*, Mr. George I. Rockwood asks, "Does it pay merely because land is expensive to put 18,000 tons of coal into a bunker 100 feet high in the air, on top of boilers of great weight in themselves, if a boiler house of only one story and of only 3,000 brake horse power can be built for $33.30 per boiler horse power, and occupies but 1.28 square feet of land per boiler horse power?"

This was offered in comment on the immense boiler plant of the Rapid Transit Station in New York City, and the 3,000 horse power plant referred to is one recently established at the Atlantic Mills, Providence, R. I., by Mr. Rockwood. In place of water-tube boilers, he used vertical boilers of his own design similar to the Manning type, and the space thus saved enabled him to place the coal bunkers on the floor, with not only a saving in the cost of foundation but in expensive steel work required to support the coal pockets when located above the boilers. Mr. Rockwood figures that the Rapid Transit boiler plant occupies 1.52 square feet of ground area per boiler horse power. This space includes the coal storage, the boilers, pumps, piping and economizers. The Atlantic Mills plant occupies 1.28 square feet per boiler horse power, including everything except the coal bins, but the economizers, boilers, and all the apparatus are on one floor, and the expense of heavy steel construction is avoided, since a building one story high and strong enough simply to support the roof is all that is required.

Before attempting to decide Mr. Rockwood's question, one must form an opinion as to the advantages of horizontal water-tube and vertical boilers. The water-tube boiler is generally conceded to be the safest type extant, and on the whole an extremely satisfactory boiler. The small space occupied by the vertical boiler is so great an advantage that it may be asked, "Are its disadvantages if any, sufficient to offset this saving in space?" In the water-tube boiler the sediment is deposited in a mud-drum, well out of the way of the hot gases, and circulation of the water is rapid; there is no probability of burning out any of the tubes. In the upright boiler, however, the tube sheet is directly over the fire, and is certain to be covered to a greater or less extent with sediment and scale. In this respect it is subjected to the same dangers as the horizontal tubular boiler, namely burning out of that part of the boiler which is directly over the fire, provided the sediment and scale are not removed. It is held, however, that the danger from this deposit is not so great in the case of the vertical boiler as in the horizontal boiler. When a section of the shell is overheated in the latter, it must be patched, and the patch and rivets come in the worst possible place for such repairs. With the vertical boiler it is hardly possible for matters to reach so bad a state. When overheating begins, the tubes and tube sheet become weakened to such an extent that leaking at once occurs around the tubes, and if the deposit gathers over the whole tube sheet, there will be a sufficient rush of steam and water to completely extinguish the fire. If, on the other hand, the heating is local, only a small quantity of water will escape and may possibly not be noticed by the firemen until the tubes in that part of the boiler have become burned. In that case they must be renewed, whereas in the former case it will merely be necessary to expand them into the boiler sheet again.

When the boilers of the Atlantic Mill plant were first used, two of them troubled by leaking, and investigation showed a thick deposit of scale, although the boilers had been thoroughly cleaned and washed out with soda water before the fires were lighted. The water was also known to be free from lime, and the explanation of the scale formed was not forthcoming at once. Later it was determined that the deposit was formed of mill scale which came from the new tubes of the boilers. We do not know whether it is common for boiler manufacturers to pickle the boiler tubes in acid before putting in place, but this experience shows the necessity of it. The boilers had been filled with water some days previous and the tubes had undoubtedly rusted slightly. The boilers were to furnish steam for a Westinghouse-Parsons steam turbine. These turbines are governed by a rapidly reciprocating valve which delivers the steam in impulses, and at first the accompanying vibration was transmitted to the piping and boilers which probably shook off the loosened particles of scale, causing the trouble. The result was one of the unexpected things that so often happen, and is apparently an element that must be considered in starting up new boilers under similar circumstances.

* * *

TIMBER PRESERVING PLANT.

The rapid destruction of the great forests of this country has forced upon the railroads the very serious problem of the supply and preservation of timber, and many efforts have been directed toward perfecting processes to preserve the ties from insects and decay. In a recent installation by the Ayer & Lord Tie Co., of Chicago, the timber being treated is placed in air-tight cylinders, where it is first subjected to steam under pressure to remove all air from the pores of the wood, after which the air and steam are exhausted by a Deane wet vacuum pump. When all vapor and gases have been removed, creosote is pumped into the tank and forced into the wood by a pressure pump of the Deane duplex type. A Clayton air compressor is next used to force air into the tank, displacing the creosote and returning it to an elevated storage reservoir. This process is said to give as good results as any now employed for tie preservation.

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MACHINERY

DESIGN—CONSTRUCTION—OPERATION.

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MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition—$1.00 a year, comprising more than 430 reading pages. The Engineering Edition—$2.00 a year—contains all the matter in the Shop Edition and about 250 pages a year of additional matter, which includes a complete review of mechanical literature, and forty-eight 6 x 9 data sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering, but is printed on thin paper for transmission abroad. RAILWAY MACHINERY, $2.00 a year, is a special edition, including a variety of matter for railway shop work—same size as Engineering and same number of data sheets.

THE PROGRESS OF THE CONNECTICUT.

The rivalry between the private shipyards of the Newport News Shipbuilding Co. and that of the Government as represented by the New York Navy Yard in the building of the two 15,000-ton battleships *Louisiana* and *Connecticut* was briefly alluded to in the November issue. There is a general public interest in the matter as there is a sentiment abroad that the Government should be in a position to build its own naval vessels, if for no other reason than to make a healthy competition. There is also a general interest in the competitive results, because the Government yard is working under the handicap of an eight-hour day, while the private yards pay less wages for nine hours of service. The disadvantage under which the Government yard works is still greater than indicated by the length of the working days, inasmuch as the employes receive full pay for about seven legal holidays, and fifteen days leave of absence during the year. This makes twenty-two days, or over seven per cent. of the total number of working days in the year for which it pays but receives no service. On the other hand the Government yard pays no interest upon the investments represented by its shops, and it has to earn no dividends, hence whatever the actual cost of the vessel, there will need be nothing added to represent interest charges, or profit.

But it may be a fact that the eight-hour day and the holidays with full pay are no more serious drawback to the Government in the competitive building of battleships than are some of the many red-tape restrictions that are thrown around the operation of its ship yards. In any manufacturing enterprise, a demand for certain materials is certain to arise that could not well be anticipated, and it will be highly desirable to get them with the least possible delay. This the Government yard cannot do. It must go through the formality of advertising for bids and must in general take the lowest bid which may or may not represent the exact product desired. At the present time the New York Navy Yard has no ⅝-inch bolts in its stores, partly owing to an unexpected demand from another quarter, and it will be a matter of some weeks before the supply can be gotten. The private shipyard could and would, if necessary, order a hundred kegs by telegraph, but the New York Navy Yard cannot order a solitary bolt without going through the formality of advertising for bids. To make government work successful it would seem, therefore, imperative to, in some way, modify these restrictions on getting material promptly as required. In general, of course, it is possible to anticipate the main wants for material and provide for them long before they are required, but it is the small matters that cannot always be anticipated that cause vexatious delays.

The progress of the *Connecticut* is satisfactory from the point of view of the amount of work done. The report of the chief naval constructor, Rear Admiral W. L. Capps, states that the *Louisiana* was 54 per cent. completed and the *Connecticut* 49 per cent. at the times of launching, which were some weeks apart, but from what we have personally learned we do not think that all of this difference practically exists. The machinery of the *Connecticut* is well along toward completion, thanks to the efficient superintendence of Captain J. A. B. Smith, who is in charge of the Steam Engineering Department. The propelling engines were completed some months ago, and are now nearly erected in the vessel, although a period of only two months has elapsed since the launching. This quick work is due to an innovation in the matter of shop erection. The usual plan is to only erect the bare engine in the shop with none of the piping and other appurtenances that require so much time for installation on board ship. The engines of the *Connecticut* were erected complete in the shops in all details as far as possible. The water and oil service piping was placed, the sheet steel lagging covers were fitted and the thousand-and-one other matters that require much time and hard labor were done in the shop under the most advantageous conditions. Again, the engines were not taken apart to the extent that is generally the case. The pistons were left in the cylinders, being clamped in the top heads so the pistons did not project much below the stuffing-boxes. The frames were separated in units of six columns each and clamped together so as to be lowered onto the keelson with practically no change in their alignment. In this way the assembling of the engines has been greatly simplified, and because of the careful work done in the shop, practically little fitting has been necessary in the erection.

An encouraging aspect of the work on the *Connecticut* which will go a long way toward settling the matter of profitable competition is the enthusiasm and hearty service of the employes. In the popular mind, unfortunately, "government work" smacks of inefficiency and dilatory ways, but the conditions that may have been notorious in the past, seem no longer to be so much in evidence. It is claimed that the political faith of an employe is not a potent factor in securing place or preferment; all machinists applying for work must register, and as men are required they must be taken on in turn from the registry list. This method, while having the drawback of compelling the officials to give employment to all comers who pass the registry requirements, does not compel them to retain incompetent help, and it shields them, *if they so desire*, from the evils of political preferment. Hence there seems to be no reason why the handling of labor in the Government ship yards cannot be as efficiently accomplished as in private ship yards, if the officials in charge are of the right sort, and in the New York Navy Yard we believe there is as keen a desire on the part of those responsible as in any private concern. There may be some surprises in store for those who claim that the private shipyard is the only place where Government work can be efficiently and cheaply done.

* * *

The first thing a machine-tender must learn is that journals and bearings cannot be run without oil, or that if they are run without it they will not last long. The necessity of lubricant on working surfaces is not, however, confined solely to structures commonly dignified by the name of machines. Many of the ordinary appliances of common use would work much better and last much longer if occasionally a drop of oil was put where it is needed. Even with this conceded there are very few who would ever think of oiling umbrella joints, but it is said to greatly increase their durability. Oiling not only makes the joints work easier but it prevents rust, which, perhaps, is more destructive than the actual wear.

ENGINEERING REVIEW.

CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH.

Some astonishing quantities of dust and dirt are reported as having been removed from apparently cleanly carpeted rooms by the vacuum or sucking process, which has previously been alluded to in these columns. The Fifth Avenue Presbyterian Church in New York City, a large edifice, was recently cleaned in this manner, the spoil being thirteen barrels of dirt sucked out of the carpets and crevices in the floors!

According to a statement in the *Philadelphia Record*, a concern has been organized for the utilization of the vast number of pine stumps that encumber the pine lands of Michigan and Wisconsin. The old stumps are subjected to destructive distillation which produces turpentine, tar, charcoal, and other characteristic products, and in addition what is said to be an excellent quality of lubricating oil. The discovery that lubricating oil can be obtained in this manner is new and this will be the first attempt to exploit the process commercially.

The experimental steel tracks laid about two years ago on Murray Street between Church Street and Broadway for the benefit of heavy trucking, have been torn up. The street has been repaved with wooden blocks and the steel rails will not be relaid. The experiment has demonstrated that steel tracks are a failure for city traffic consisting of horse-drawn vehicles. Although the rolling resistance to the wheels is greatly reduced with them, they were found to be a great menace to the horses. Horses frequently slipped and fell, sometimes breaking their legs or otherwise seriously injuring themselves. The use of the steel highway will become practicable only when the horse has been displaced by the self-propelled vehicle.

The *National Provisioner* says that glue, when combined with chromates and exposed to light, loses its solubility in water, and can, therefore, be used as a cement for articles exposed to moisture. The following is a suitable formula: White glue, 5 to 20 parts; water, 20 parts; potassium bichromate, one to two parts; water, 10 parts. Make the solutions of the glue and of the potassium bichromate in separate portions of water, as indicated above, the glue being dissolved by heat; stir in the solution of bichromate; mix well and then pour the mixture into tin boxes and allow it to congeal therein. For use, take a sufficient quantity of the glue, melt in a cup standing in boiling water; place a layer uniformly on the fractured surfaces, press them together, and expose the articles to the sun for a few hours.

A writer in *Sparks* intimates that low-carbon steel, say about .75 to .80 carbon, will harden deeper than high-carbon steel containing 1.30 to 1.35 carbon. Low-carbon steel has a much higher heat conductivity and a lower specific heat than high-carbon steel, and these reasons alone may account for the difference, although it is probable that the difference in the chemical action of the constituents of the two steels is also partly responsible. The heat conductivities of .50 and 1.33 carbon steel are about as 2 to 1; hence a large piece of steel of low carbon will give up its heat in the bath appreciably quicker than one of high carbon. It also has a slightly lower specific heat so that it contains from 1 to 2 per cent. less heat to give up. There is a surprising difference in the thermal conductivity of hard steel, soft steel and wrought iron, the coefficients being 0.062, 0.111 and 0.152 respectively.

One of the interesting applications of concrete is that of using it for setting posts and similar work, which, if set in the ground unprotected, would soon rot away. A wooden post treated with tar and set in a hole on a flat stone and surrounded by a firmly tamped bed of concrete is practically indestructible and will furnish a sound, substantial foundation for years to come. The same plan is used to some extent in setting of trolley poles, especially, when made of iron. The small diameter of the pole does not give the necessary stability to prevent its being racked out of place by the surging of the trolley wire. But if an ordinary hole dug for such a pole is filled with concrete it forms a mass 25 or 30 inches in diameter and of a length equal to the depth of the hole, which is solidly united to the pole, giving the latter several times the stability that it would have if set in earth alone. Moreover, the concrete preserves the iron for practically all time against corrosion, and it might reasonably be expected that poles so set may rust away above ground before the portion protected by concrete is appreciably affected.

From time to time, says a recent consular report, great efforts have been made by manufacturers and other producers to get rid of the middleman in trade, but so far these efforts have been of little avail. This has been particularly the case in Japan, and those manufacturers in America and England who have believed that they could benefit themselves by eliminating middlemen have had some disastrous experiences. Salesmen have been sent to Japan with this object in view, and endeavors were made to open up direct relations with the Japanese consumers. The result oftentimes has been the wasting of valuable time on commercial letters from students, schoolboys, and other irresponsible parties, whose motive in writing was merely that of curiosity or to get catalogues without the remotest idea of ever ordering goods; or orders have been filled from firms of no commercial standing with the obvious result of getting a lot of bad accounts. Theoretically, no doubt, the existence of the middleman is an economic loss, it being true that he produces nothing while he makes his living. Yet in practice it is found that his knowledge of markets and of business gives him a position in the social economy which would be difficult to otherwise fill. In other words he lubricates the wheels of business; machinery works with less friction with the application of oil, although the oil is not absolutely necessary to make the machine work.

Like most great and enduring enterprises Lloyd's had a small beginning. It is now to the world of shipping and marine insurance what the house of Rothschild is to the banking world. Lloyd's dates from the latter part of the reign of Queen Elizabeth, and had its origin in a small coffee house in Tower Street, kept by Edward Lloyd. He was an enterprising man, and through his business contact with seafaring men and merchants enlisted in foreign trade, foresaw the importance of improving shipping and the method of marine insurance. He was the founder of the system of maritime and commercial intelligence which has been developed into its present effectiveness. Before the time of Edward Lloyd maritime insurance in England was conducted by the Lombards, some Italians, who founded Lombard street, but after Lloyd embarked in the business, Britons conducted marine insurance in London. Lloyd's moved to Pope's Head Alley in 1770, and in 1774 removed to the present quarters in the Royal Exchange. In 1871 Lloyd's was incorporated by act of Parliament. This act defined the objects of the society to be: (1) the carrying on of the business of marine insurance by members of the society; (2) the protection of the interests of members of the society in respect of shipping, cargoes, and freights; (3) the collection, publication, and diffusion of intelligence and information with respect to shipping.—*Consular Report.*

In the transactions of the Lake Superior Mining Institute, Mr. James R. Thomson refers to the very difficult conditions under which deep mine hoisting engines operate. For instance, the big Nordberg quadruple engine hoist at Tamarack lifts from an approximate depth of 5,000 feet and makes from eighteen to twenty trips an hour, thus giving the skip or car an average rate of travel of about 35 miles per hour. The work is of such a peculiar nature that compound or triple

expansion engines are unfitted for it. The load consists of the weight of the ore, the weight of the skip and the weight of the rope. This latter weight is greatest when the skip is at the bottom of the shaft, and decreases as it nears the top. The engine must start with the maximum load, attain full speed in six or seven revolutions, and stop short all within, say, one minute, and after a longer or shorter period of idleness must repeat the operation. Lake Superior hoisting experience has fully demonstrated that simple Corliss engines or other engines of automatic variable cut-off give more economical results than fixed cut-off engines. The economy of using compound or triple expansion engines is indefinite and negative. In this connection the Rateau regenerator and steam turbine work a considerable economy in hoisting plants. The main engines exhaust into a closed regenerator and from this the steam supply of a steam turbine exhausting into a vacuum is taken. The turbine drives an electric generator which supplies current for lights, auxiliary apparatus, etc.

An important difference between the construction of wire ropes and hemp ropes is in the laying of the strands. From time immemorial hemp ropes have been made with the twists of the strands opposite to those of the rope, the object, of course, being to prevent unraveling. Wire ropes were originally made in the same way, but a few years ago a construction known as "Lang's lay" was introduced, in which the twists of both the strands of the wire rope are in the same direction. This makes a very important difference in the wear of ropes running over pulleys or sheaves. In a wire rope made like a hemp rope the wear is concentrated on the crowns of the wires where they pass over the top of each strand, since this portion is the one that comes in direct contact with the sheave groove. In the Lang's lay system the crown is not so acute, and a much larger continuous surface of any wire is exposed to the wearing action, that is, the wear is more nearly parallel with the length of the wires. Oiling wire ropes also has a great effect upon their life. Tests made on ropes oiled and unoiled have demonstrated that oiled ropes will give from two to five times the service of those unoiled. But perhaps the greatest factor in the life of a wire rope is the diameter of the sheave over which it runs. If the diameter of the sheave is so small that with ordinary loads the elastic limit of the outer wires of the rope is exceeded every time the rope passes over the sheave its life will be very short. But if the diameter of all sheaves is made at least 40 times that of the rope, its life will be long.

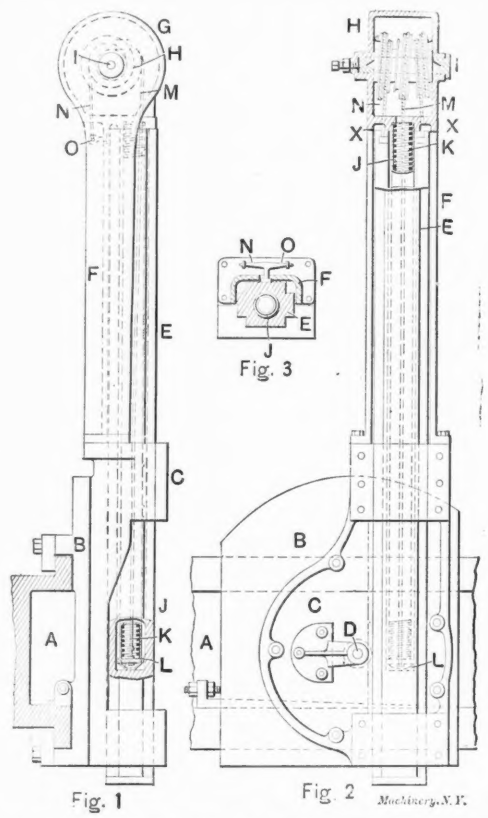
COLD-SOLDERING BANDSAWS.

The brazing of bandsaws with silver solder is an operation requiring considerable skill on the part of the workman, and is an objectionable process because the high temperature necessary to melt the silver solder also draws the temper of the saw at the joint. One of the junctures where the tempered and untempered parts of the blade join is likely to be the point where the next break takes place. Since the breaks are repaired by making lap joints, it follows that a saw becomes shorter and shorter with each repair, and after it has broken a number of times it is shortened so much that it can no longer be used without inserting a new piece, which is objectionable as it makes two joints instead of one to give trouble. A so-called "cold-soldering" process for bandsaws is being exploited by a British concern, that is of interest. By the new process, to which the name "Forkor" has been applied, the joint is made by a method of cold-soldering which is very simple, and requires no apparatus beyond a clamp, spirit lamp, and a pair of broad-faced pliers. The broken ends of the saw are, first of all, filed for a length of from three to four teeth, and then brushed over with a white fluid, the composition of which is at present a secret. The ends, thus coated with the liquid, are warmed by the spirit lamp and rubbed with a stick of solder until the surface is well covered with metal; after which a second layer of the liquid is applied. The ends are then clamped in position and heated again until the solder melts, and are then pressed firmly together with the pliers to squeeze out the excess of solder. After dressing with a file the saw is ready for use.

The advantages of the process, says the *Engineering Review*, are that the temper of the saw is not affected, and should a break occur again it always takes place at the joint. As, therefore, there is no shortening of the saw, it can be used for a much longer period than would be possible were the brazing process used. The time occupied is less than half that necessary for brazing, and, moreover, the saw can be used at once. The cost of making a joint, it is claimed, does not exceed two pence.

BALANCING ARRANGEMENT FOR THE RAMS OF BORING MILLS.

In boring and turning mills the ram or tool holder is usually balanced by means of a cord or chain and weight, but this arrangement is not all that could be desired. To provide a better arrangement the spring balancing device shown in Figs. 1, 2, and 3, has been designed and patented by J. E. Mathewson, of Broadheath, near Manchester. Referring to the illustrations, which with the description are copied from the *Mechanical Engineer*, *A* indicates the cross slide of the machine, the construction of which is well known; *B* is the saddle, and *C* is the ram frame which is pivoted at *D* to the



Balancing Arrangement for the Rams of Boring Mills. See "Machinery," March, 1904.

saddle. *E* is the ram or tool holder which slides in guides in the frame *C*. On the top of the frame *C* is secured a support *F* which supports the box *G* containing the fusee or equivalent equalizing device *H* and the bearings for an axle *I* carrying the same. The ram *E* is hollow, and contains a coiled spring *J* inclosed by a tube *K*. The spring at the top abuts against the under side of the box *G*, and at the bottom rests on a cylindrical block *L* to which the cord or flexible connection *M* is attached. This cord after passing round a fusee is secured to the axle *I* in any convenient manner. On the same axle there are mounted two fusees to which cords *N* are attached, the other ends being secured to arms *O* secured to the back of the ram *E* and extending through a slot in the ram guide, as shown clearly at Fig. 3. As the ram *E* is lowered to bring the tool to its work the axle *I* is rotated by the fusees, and the spring *J* will be compressed through the cylindrical block *L* which is drawn up by its cord *M*, and when the ram is released the spring will return it to its normal position, all of which movements will be clearly understood on reference to the cut.

THE "AUTOPYROPHON."

The "autopyrophon," is a new and simple automatic fire alarm which acts only when a sudden wave of heat is generated in an inclosed space, but is not influenced by a general and evenly high temperature. It is only 3.94 inches high, 2.76 inches broad, and 0.78 inch deep, hence it can be easily fixed anywhere. It consists of a small glass tube bent in the shape of a capital U. This tube, the ends of which are closed, is half filled with mercury, the other upper half containing a highly volatile liquid—for instance, sulphuric ether. One of the upper parts of the glass tube is surrounded by a cover of some non-heat conducting material, so that a sudden rise of temperature affects only the other or free part of the glass tube. In case the temperature rises evenly the whole apparatus is affected and no warning signal is given. If, however, the temperature in the room is suddenly raised, as by the outbreak of a fire, the ether above the mercury in the glass tube, which is unprotected, evaporates, and the pressure of the generated vapors causes the mercury to sink in the tube while it rises in the opposite part. Both parts of the tube are fitted with an electric wire fused into the glass, so that when the mercury stands equally high in both tubes the electric current passes through and the apparatus remains silent, but should a movement of the mercury take place because of a sudden rise of temperature, the electric circuit or contact is impeded, and any kind of electric alarm may be set into motion at any distance and at as many places as required. The apparatus also indicates impediments and interruptions of the electric current. The substances need no renewal and the apparatus acts an indefinite length of time.

The United States Consul-General of Munich, Germany, who was present at a recent demonstration of the device, states that the alarm was raised within eight seconds from the time a small heap of shavings was set on fire in the corner of an ordinary sized room. In this case the apparatus was fixed near the ceiling at the end of the room, opposite that where the shavings were burning. It is calculated that one apparatus which costs about $3.00 is needed for an area of 600 to 800 square feet.

RADIAL STAYBOLTS FOR OIL-BURNING BOILERS.

Railway Master Mechanic, October, 1904.

It has always been a serious problem to maintain locomotive boilers on oil-burning engines owing to the increased intense heat over the coal-burning engines. Radial staybolts have been the greatest source of complaint, owing to their leaking, and heads dropping off, and this has compelled the railroads to substitute a bolt which will withstand the enormous strains under oil-burning conditions. With radial staybolts having large button heads, the most trouble experienced has been that the heads drop off after they have been calked but a short time, and also on account of too much iron at a

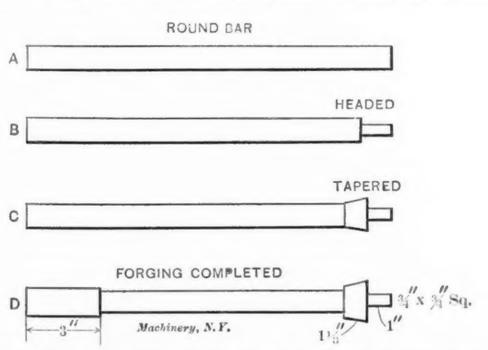


Fig. 1. Successive Steps in the Forging of a Radial Staybolt.

point too far away from the water. When the burning oil is shut off the only heat retained in the firebox is in the brick arch and brick walls. This heat is not sufficient unless a good fire is retained, and the boiler is caused to contract very rapidly. The stresses set up by these alternate expansions and contractions are very severe. Unless the handling of the engines, and the keeping of a regular fire are watched very carefully, radial stays, staybolts, and flues give much trouble by getting loose in the holes.

A bolt which is now being used on several railway systems is shown by the accompanying line drawings, which also illustrate the method of manufacture and application. The crown sheet end of the bolt is made tapering and is cut very close to the sheet and hammered up well, thereby making it safe as well as steam tight. This bolt up to the present time has been found to meet the requirements better than any other bolt yet tried.

These staybolts are made on the bolt header in the blacksmith shop, and taken direct to the bolt cutter in the boiler shop and finished complete, with the exception of nicking,

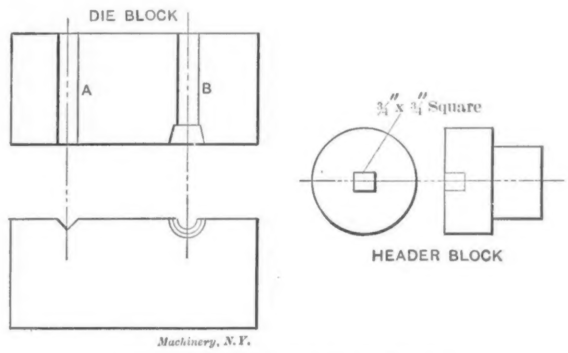


Fig. 2. Die Block and Header Block.

which is done in a small chuck lathe, made especially for this purpose. By this process the lathe work is entirely dispensed with.

Taper staybolts, as applied in the San Bernardino shops of the A., T. & S. F. Ry., are of the form shown by Fig. 6, of proper length and diameter to fit holes. The straight-thread part is somewhat larger than the body of the bolt, and the taper end has a flare of about one-eighth inch to the inch. A square head is forged at this end to permit the application of a wrench in placing the bolts. These staybolts are forged in an "Ajax" bolt-header, the die block being of the form shown by Fig. 2, with a triangular groove *A* and a countersunk cavity *B*, of shape and dimensions determined by the size of bolts to be headed. The rough bar, of the desired length, is first squared for a distance of one inch at one end. The bolt is then placed in position in the cavity *B* and the heading die-block having a cavity to fit the square head of the bolt, forces the hot bolt into *B*, forming the flared end. The straight end is formed in the usual manner in a straight block. The successive stages of the operation of forging are shown at *A*, *B*, *C*, and *D*, in Fig. 1.

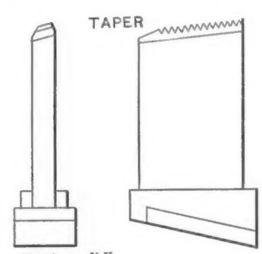


Fig. 3.

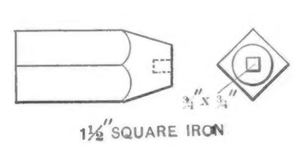


Fig. 4.

The holes in the sheets are tapped with a spindle tap, both threads being cut in one operation. The threads in the two sheets come in perfect alignment and are continuous. In order that the staybolt may follow the threads of the two holes, it is necessary that the threads at both ends of the staybolt be continuous, that is, they must "catch up." These threads are ordinarily chased in a lathe, which insures this condition, but a very simple and effective device makes it possible to cut these threads in a double-headed staybolt cutter; in this way a considerable saving in cost is effected. Tapered dies are made for the bolt cutter of the required sizes, as shown in Fig. 3. The staybolt is placed in the machine with the tapered shank in position for cutting in the dies, held in a simple chuck, shown by Fig. 4. This chuck has a cavity of the proper size to hold the square head of the staybolt, and is rounded and tapered at that end to allow it to follow the staybolt into the dies. This chuck is held in the vise of the machine, and the bolt forced into the dies, which

are regulated in the usual manner for the proper diameter to fit the tapped holes. After the thread has been cut on the tapered end of the bolt, it is placed in the vise, being held at about its middle with the straight shank in position for threading. The dies are, of course, changed to the straight cutting form. Placing the bolt haphazard in the vise will not insure making the threads "follow," and consequently a gage, as shown in Fig. 5, is used to accomplish this end. This gage consists of a block *A*, held on a spindle *B*, by a setscrew. The block *A* is threaded the same as the staybolt, but the taper is reversed to allow the threads to mesh with those of the tapered end when in position. The shoulder *C* is made to rest in the jaws of the vise while holding the staybolt in position for cutting. The distance *D* from the shoulder to the bottom of any thread on the block *A* is set so that it will contain a whole number of threads. For example, if twelve threads per inch are used, *D* would be set in inches and twelfths, etc. This

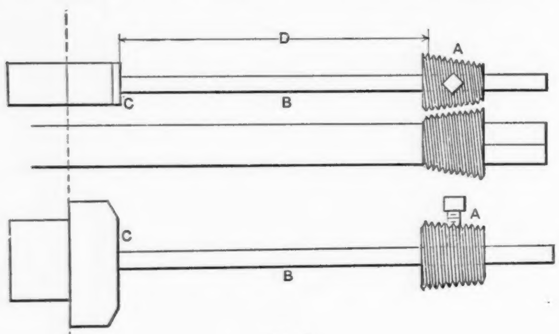


Fig. 5

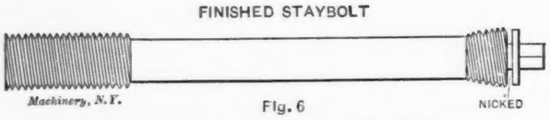


Fig. 6

Method of Locating Staybolt by Gage—Finished Staybolt.

having been done, the distance from the shoulder in the other direction, to the threads on the other end of the staybolt will also be such as to contain a whole number of threads, and the requirement is fulfilled that the threads shall follow, and the staybolt will fit the threads of the holes.

The threads on both ends having been cut, the staybolt is placed in a small cutting-off machine, and nicked just under the head, so that the square head may be easily chipped off after the bolt is in place.

[These staybolts are, we infer, cut in a bolt cutter having a leadscrew which positively controls the movement of the carriage. The gage shown in Fig. 5 must first be adjusted by a staybolt in perfect lead, *i. e.*, one cut in a lathe. It is located in the correct position in the vise by closing the dies on the straight-thread end, and the gage is then set by it; it in turn serves to locate the staybolts as explained.—EDITOR.]

EXPERIMENTAL WORK ON SOLID EMERY WHEELS.

Extract from Paper presented by Mr. T. Dunkin Paret at the May 12, 1904, meeting of the Franklin Institute.

The main cause of bursting emery wheels is heat, but just how heat operates is somewhat of a mystery. The conclusion seems natural that wheels which are poor conductors of heat are the most unsafe. In such wheels the heat created by friction at the circumference works slowly toward the center, and the outer rim expands with speed disproportioned to that of the center. Such expansion might result in cracks transverse to the face and other cracks radiating from face to center. As a matter of observation, the wheels which are unsafe are those whose substance conducts heat easily, and which quickly get hot all through. Such wheels throw off broken edges and irregular chunks, and burst without any definite system of cracks. It follows from this that wheels entirely mineral are not, as a class, so safe as those in which the mineral grains are surrounded and separated by gums, glue, and other organic matter.

The adhesion of metal to the surface of the wheel is also, to some extent, an effect of heat. It may be that wheels with this defect overheat and soften the metal, or the adhesion may be due either to the chemical constitution of the wheel or its physical structure. It is a clearly ascertained fact that free-cutting wheels are not characterized by such adhesion, and that slow-cutting wheels are. It is also evident that as the metal increases in heat the cut (or product) decreases. It is seldom that the end of a ¾-inch by ½-inch cast-iron bar is much reddened by the grinding of a free-cutting wheel, and the edges of the bar are generally clean-cut. Under the same conditions wrought iron gets red-hot for a considerable distance, and flattens out and bends over at the edges.

Many years ago an experimental test machine was built in which the metal was forced against the wheel by a continuous screw feed. As the bar elongated with heat, the pressure increased, and with increased pressure increased heat was generated. Under these conditions the bar became intensely hot and red, and the wheel almost ceased to cut.

Complicated with these questions of heat is the subject of contact area and clearance. The ideal conditions of grinding are those in which wheel and work come in contact on a narrow line. A thin edge of saw steel will be ground rapidly and effectively if pressed against the face of a wheel, while a large flat surface shows little product if pressed against the side. While this is partially due to the vastly greater pressure per square inch in the case of the thin edge, it is also due to the lower heat which results from proper clearance. In the case of the thin edge all debris of wheel and metal fly instantly away, each grain removing its quota of heat. In the case of two large flat surfaces rubbing together the debris is retained (with its included heat) and is bruised into the interstices of the wheel, interfering with its cut. For this reason it is a radical mistake to fit wheel and work in such way that large surfaces are in contact. Cone wheels exactly fitted to corresponding interior metal surfaces (axle surfaces, for instance) are a mistake. So would be large curved grinding blocks, if applied like brakeshoes to the curved face of a carwheel.

The tread of car wheels has long been ground in a practical way with an ordinary disk-shaped emery wheel, the curved exteriors merely touching on a narrow line and affording excellent clearance for wheel and metal debris. For this process, some years ago, was substituted a grinder, in which cup-shaped wheels were used. When the writer of this paper saw that machine in operation, a keg of grain emery stood close at hand, and the operator from time to time dropped some of it between the car wheel and the emery wheel. Questions and further examination brought out the fact that flecks of metal adhered periodically to the emery wheel, and that no proper work could be done until these were removed by the use of the loose grain emery. It was stated that the formation of a single fleck could be heard at the most distant corner of the shop, and this proved true. It was also stated that, when the rims or cutting edges of these wheels were pretty well worn down, such rims were removed entirely, and the wheels transformed into ordinary disk wheels. In this altered form, when the convex exterior of the grinding matter was used instead of its flat side, the wheels did good work and no metal adhered to them.

In the absence of verified data as to the relative cutting capacity of small and large wheels, it is well to point out the manner in which circumference and mass modify the effects of frictional heat. The circumference of a 6-inch wheel is about 19 inches; that of a 36-inch wheel about 113 inches. A wheel 6 inches by 1 inch contains about 28 cubic inches; a wheel 36 inches by 4 inches about 4,000 cubic inches. The standard speed of a 6-inch wheel is 3,600 revolutions per minute; that of a 36-inch wheel 611 revolutions. If a bar ¾ inch by ½ inch is ground on these wheels the heat problem will be different in each case. At the first moment, when bar and wheel come in contact at heavy pressure, intense heat will be developed. In the 6-inch wheel this spot (each and every point of contact) will be heated 3,600 times in a minute, while in the 36-inch wheel it will be heated only 611 times. Though both wheels travel at the same surface speed, the circumference of the 36-inch wheel is so much greater

that it has about six times greater ability to cool. The greater area of its surface causes greater radiation and loss of heat, while that which remains has about 4,000 cubic inches of matter to diffuse itself through, instead of the 28 inches allotted to the 6-inch wheel. If, therefore, frictional heat is an undesirable thing, the advantage of large wheels becomes evident.

There is *apparently* one clear deduction from these facts, and this is that water should be used to prevent the injurious effects of heat. Nothing can be more erroneous than this deduction, and nothing has done more to retard the proper development of grinding processes. The use of water on solid emery wheels is a survival of the old Sheffield methods, in which huge grindstones are run in a stream of water, in which the workman straddles a board that presses his work against the stone, in which the heaviest man is the best grinder.

The use of water has been urged indiscriminately as an excuse for an increased variety of grinding machines, and, in times past, as a method of using emery wheels too weak and poor to be used dry. It is not an uncommon thing to read, in commercial literature, that certain wheels can be used equally well wet or dry. In justice to the getters-up of such vague assertions, it is assumed here that they are not intended to imply equal products by the wet and dry processes. It is to be feared, however, that the long-continued and oft-repeated assertion of this generality has created a false impression.

In opposition to any such view, it should be stated in the strongest way that water is a lubricant. Exact data on this subject seem to be almost entirely lacking, but the only ones known to the writer (and procured under his supervision) are now given. Seven different makes were tried under conditions identical except as to the fact that in one series the wheels were used dry and in the other series wet. Sixteen consecutive, intermittent cuts were made by each wheel in each series of trials, the speed being about one mile per minute, the pressure about 112 pounds per square inch, and the material ground cast iron. The total product of five of these wheels under the dry process was 186 12-16 ounces, while under the wet it fell off to 24 13-16 ounces. Two (out of the seven) wheels gave a larger product under the wet process than under the dry, but this result confirms the facts previously adduced as to over-hard wheels and the lessened product due to metallic adhesion. In 32 minutes these two wheels ground off, under the dry process, 2 2-16 ounces, and, under the wet process, 10 2-16 ounces. It seems evident that in this case the use of water lessened the metallic adhesion.

The fact is that water is only necessary to protect metal from the effects of heat. Where there is danger of warping in some article held while cold under the stress of undue tension, or where some desired temper is altered, water can be advantageously employed, but its indiscriminate use (on tools, for instance) encourages careless methods. The dry process carries on a steady educational work, the grinder acquiring increased delicacy of touch and greater knowledge as to the contraction, expansion, density, stress, and temper of metals.

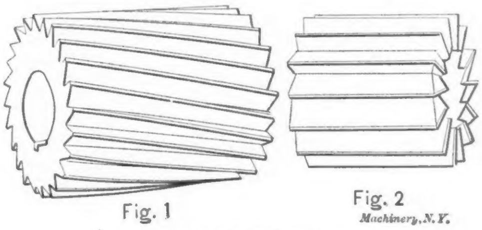
It is a too common assumption that tools cannot be properly sharpened on a dry wheel, yet experienced operators can produce any desired temper by the skilful use of the dry process. The tempering furnace has been (in at least one instance) abandoned for a tempering wheel, and saws have been given an increased durability by the special hardness due to careful use of a dry wheel.

The advantages of intermittent pressure, as affecting the heat problem, are very evident, and the disadvantages of grinding with a flat surface have been pointed out. The facts that high-speed is connected with a free cut, and that a free cut generates the least heat, are well understood. It will, therefore, be readily perceived that if a knife edge is ground on the flat surface of a wheel at half speed, under an unyielding screw feed, all the elements of temper destruction are present. Nevertheless, a 2-foot planer-knife, with bevel 13-16-inch wide, has been successfully ground on an automatic knife-grinding machine with a dry wheel, under the disadvantageous conditions just stated. The record states that such grinding did not blue the knife, which remained cool enough to handle. If a machine can do this, what will not the sensitive and delicate hand of a skilled workman accomplish?

THE SHAPING, GRINDING AND HARDENING OF MILLING CUTTERS.

Zeitschrift fur Werkzengmaschinen und Werkzenge, May 5, 1904, p. 316.

The milling cutter plays a most important part in the modern workshop and a great deal of attention has been devoted during the past twenty years to its development. In the care of these tools the methods have grown from the use of the file for dressing and shaping to the almost universal employment of the emery wheel for that purpose. These cutters may be divided, according to the work that they are intended to perform, into two main groups; the axial cutter, as shown in Fig.



Axial and Radial Cutters.

1, and the radial miller of Fig. 2. The first works on a plane parallel to its axis, and the latter on one at right angles to the same. The form of the teeth in the two also differs: For example, we make the cutting angle, *B*, of Fig. 3, and the clearance angle, *c*, the same as that of a flat chisel for use on the same metal, while the angle of rake for cast iron runs from 0 to 2 degrees, and that for wrought iron about 5 degrees. The clearance angle had best be the same for all cutters, and for both metals from 5 to 8 degrees. In the matter of the form of the clearance surface, *R*, there should be a difference between the two kinds of cutters. Ordinarily a tooth of triangular section is used; though, for form cutters, the trapezoidal as in Fig. 3, is also found. It is well known that the face of the tooth *s* is the place where the grinding is done in the case of the tooth that is to be maintained in constant shape, and the angle of rake must then be kept equal to 0 degrees. The teeth of ordinary cutters on the other hand are sharpened on the back. It is, therefore, easily seen that, in the first method of sharpening it is necessary to remove much more metal than in the latter

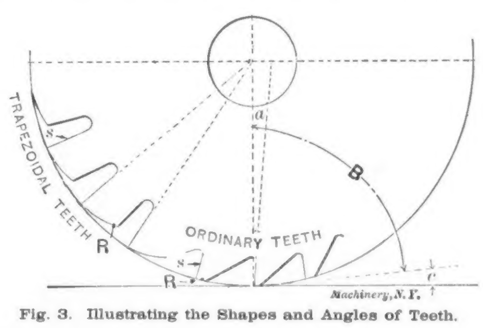


Fig. 3. Illustrating the Shapes and Angles of Teeth.

with the result that much more is wasted. This is shown graphically by the hatched portions at the cutting edges of the ordinary and trapezoidal teeth shown in Figs. 4 and 5.

In the cutter with teeth of the ordinary form, the angle of rake *a* is fixed. It is, however, by no means a matter of indifference as to the form of cutter that shall be used in shaping the teeth. Figs. 6, 7 and 8 show the three forms of cutters that may be used in shaping the teeth on a cylindrical surface. In the forms shown in Figs. 6 and 7 one of the cutting surfaces lies at right angles to the axis of the cutter. In this it is of importance that the end cutting section *a* should work upon the face of the tooth as in Fig. 6. On the other hand, it is a great disadvantage that the points of the teeth should be so exposed that they cut a more or less jagged surface on the face of the cutter. A better arrangement is that shown in Fig. 7, where the cutters for the front of the tooth run parallel to the

same. A better piece of work can be done with a cutter shaped like that shown in Fig. 8, where both surfaces are worked out by cutters running parallel to them. The adjustment of such a cutter can best be made by means of a sheet metal templet like that shown in Fig. 9. It should be provided with a hub, *N*, whose hole will fit over a mandrel or stud run through the center of the cutter to be milled. The angle *a* for cutters intended for use on cast iron had best be made of from 3 to 6 degrees, according to the rake that is desired. The number of teeth, their pitch and depth are, for the most part, left optional, with the result that even in large and well-built machines there is a great deal of chattering.

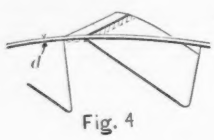


Fig. 4

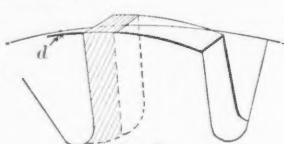


Fig. 5

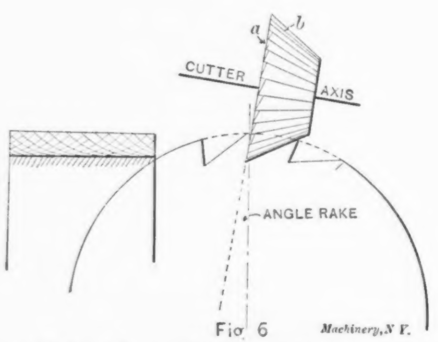


Fig 6

Relative amount of Metal Removed in Sharpening—One Form of Cutter used for Shaping Teeth.

No hard and fast rule can be laid down for this work, and existing practice is quite varied in its details. In his own practice the writer has taken quite a simple course: The diameter, *D*, of the cutter is first obtained; this depends upon the work to be done and should be as small as possible. The thickness of teeth, *t*, should then be determined from the following formula that has been derived from practical experience:

$$t = \frac{D}{10} + c$$

For cutters up to			2	inches diameter	$c = \frac{3}{16}$	inch.
" "	from 2	inches to	4	" "	$c = \frac{5}{32}$	"
" "	" 4	"	" $4\frac{3}{4}$	" "	$c = \frac{1}{8}$	"
" "	" $4\frac{3}{4}$	"	" 6	" "	$c = \frac{1}{16}$	"
" "	" 6	"	" $7\frac{1}{4}$	" "	$c = \frac{1}{32}$	"
" "	" $7\frac{1}{4}$	"	" 8	" "	$c = 0$	"

In order to determine the number of teeth, the nearest whole number to the quotient of $\dfrac{3.1416\ D}{t}$ should be taken. Thus for a cutter of 4 inches diameter we would have 24 teeth and this would cause a modification of the calculated thickness of the tooth from .55625 inch to .5027 inch.

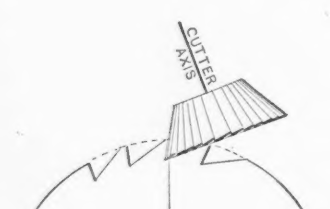


Fig. 7.

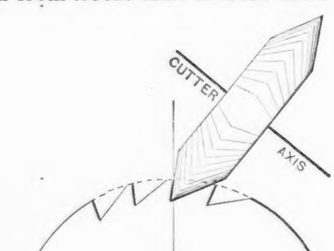


Fig. 8

The exact clearance angle, *c*, Fig. 3, should be given to the tooth by grinding. The grinding of the ordinary milling cutter is done in three ways, each of which has its advocates. In the first and oldest methods it is done at the back on the face of the clearance angle, as shown in Fig. 10, with a small emery wheel, which should, however, have as large a diameter as possible, so that the surface may not be ground hollow. This concavity of surface is the principal objection to this method of grinding, but on the other hand the defect can be readily obviated if the axis of the emery wheel in the horizontal plane is made to stand at a slight angle with the axis of the cutter, as in Fig. 10, instead of parallel to the same, and especially if the cutting face is turned in a direction opposite to that of the inclination of the cutting edge. A special difficulty is to be found in this as well as the other methods of grinding in so adjusting the wheel that the proper clearance angle, *c*, will be given to the tooth. In fact one is dependent entirely upon an inspection or test and the experience of the workman. If the teeth are of the ordinary form, and do not vary essentially from that called for in the rule given above, the clearance angle can best be tested by means of a straightedge laid over two teeth, as shown in Fig. 11, in which the clearance surface of tooth *l* should coincide with the face of the straightedge. If the teeth are pitched closer together than the rule calls for, the angle should be sharper than that of the straightedge. It is also important that the guide, *s*, Fig. 10, by which the tooth being ground is held in place and which governs the position of the tooth relatively to the emery wheel, should be brought to bear against each and every tooth and not against every second tooth, as is the case in common practice. For the sake of convenience this precaution is frequently neglected, with the result that the grinding is not the same on all of the teeth.

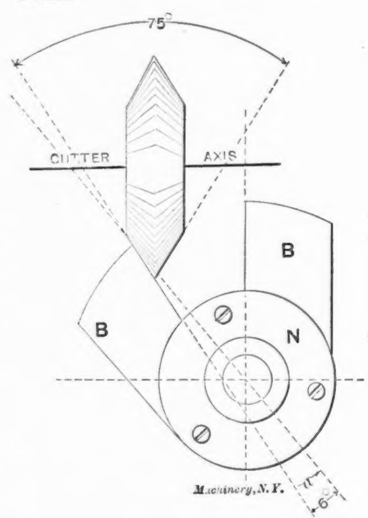


Fig. 9.

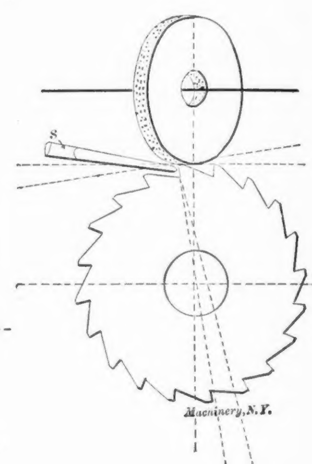


Fig. 10.

It is partly to overcome the trouble of hollow grinding and partly to obtain an accurate alignment of the clearance surface that Reinecker, of Chemnitz (and others), uses a hollow wheel cutting on the surface, as shown in Fig. 12. By this method all of the teeth are worked down with the end surface of the wheel, and so must be perfectly flat and true. A further advantage of this method lies in the fact that the overhang of the spindle may be less and a more steadily running wheel thus obtained.

Furthermore, the clearance angle, *c*, can be very readily determined by an examination so that it may be regulated by a fine adjustment of the guide, *s*, against the tooth that is being ground. The greater surface of wheel in contact with the tooth, however, increases the danger of heating, and for that reason the use of the hollow wheel is sometimes specifically forbidden.

The third method consists in the grinding of the tooth on the front and back at the same time. It is done in exactly the same way as the work of cutting the tooth in the first place, except that, instead of the milling cutters used, as in Figs. 7 and 8, an emery wheel is used, as in Fig. 13. Special automatic machines are built for this purpose and the advantages claimed are that the height of the tooth is not decreased, because of the fact that the wheel is at work on two surfaces so that the cutter does not have to be reheated and rehardened after a short period of wear. This advantage disappears, however, because it has been ascertained that the deepening of the tooth

by grinding requires the removal of so much metal that a great deal of time is required, if, indeed, the whole center is not thrown out of shape by the heating that results from such a grinding. So that the consensus of opinion is that one of the first two methods of grinding on the clearance edge is that to be preferred.

It is of the utmost importance that this grinding should be done on a well-built and reliable machine, for no machine having to do with milling can so easily get out of adjustment and do bad work as an emery grinder; and then, when bad

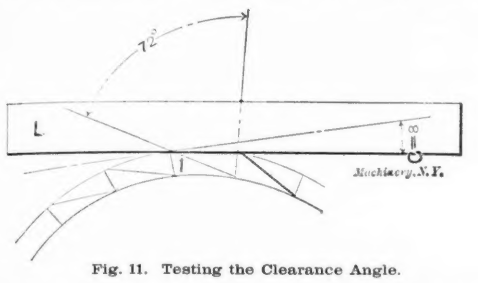


Fig. 11. Testing the Clearance Angle.

work has been done, it is usually first detected when a job has been spoiled in shaping. Good emery grinders and skillful operators of the same are, therefore, quite as important as the milling machines and cutters themselves. It is, then, not only necessary that the cutting and clearance surfaces should be ground to the proper angles but that the grinding should be so carefully done that the edges of the teeth shall not be heated. If, during the grinding with an emery wheel, the teeth of the cutter are heated to such an extent that they turn blue, the grinder can easily obliterate all traces of his carelessness, by simply passing the wheel once gently over the surface, and then it will not be detected until some defective piece of work is turned out, when the workman and foreman will be more apt to attribute it to the faulty hardening of the cutter than to the man who ground it. For these reasons it is not well to grind the face of the tooth, because overheating is at once visible and the workman has a chance to cover the mistake. The simplest means of avoiding heating in grinding is to use a wet wheel—a method that is most feasible with the Gould & Eberhardt machine where a strong stream of water may be directed against the work, and not one drop be thrown out. It has also been frequently observed that of all things connected with the careless handling of the grinding machine, the overheating of the stock is the most common. An efficient wet-

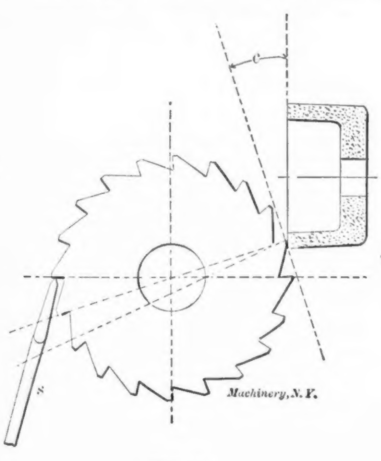


Fig. 12.

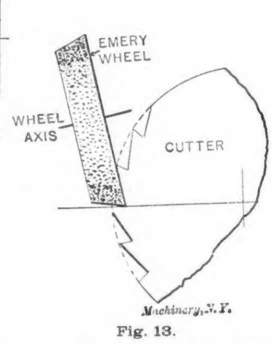


Fig. 13.

grinding machine for working on all sorts of ordinary milling cutters, does not seem to have been brought out as yet and therefore the field is open to some skillful designer to fill the gap.

By careful watchfulness over the grinding machine, faulty grinding can frequently be avoided. If, for example (it may be remarked in passing), a strong stream of sparks is produced in the sharpening of a cutter, it is safe to conclude that too much metal is being removed at a time, and that the cutter will be heated and left out of round. Again, if, when at a short distance from it, the emery wheel is heard to work with a series of dull blows, it will be found that it is not cutting, but is merely sliding over the teeth of the cutter and heating them. A noisy emery wheel is either dirty or glazed over and must be turned down, else it is hard and fine grained. A properly working emery wheel produces a steady ringing tone, which is recognized at once as evidence that it is cutting. In short, wide-open eyes and sharp ears are the most efficient assistants to the careful grinder.

For a long time, now, milling cutters of large diameter have not been made of a single piece, but with a number of inserted teeth. The fastening of these teeth in the cutter head is accomplished by means of screws, keys or by casting them in. Experience with certain forms of these inserted teeth has been that with the ordinary forms of axial and radial cutters, the pitch must be made greater, and the teeth stronger. Hence the shape shown in Fig. 14 has been developed, which differs slightly from that shown in Fig. 3, in that the clearance surfaces are made broader and the curve at the root of the tooth sharper. The difference from the form of Fig. 3 is really very slight; for, in place of the curved clearance surface, *R*, it is straight. Teeth of this form are made in the same way as those of Fig. 3, with the exception of the clearance surface, which is first cut with a miller and then, after hardening, is ground with a hollow wheel, as shown in the second method, Fig. 12. Milling

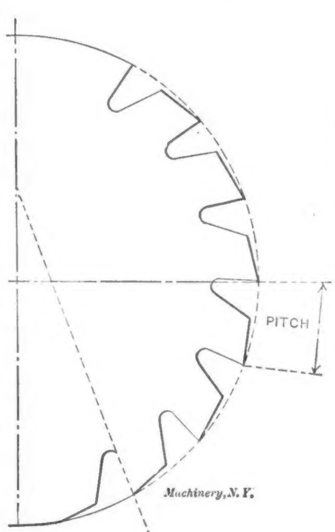


Fig. 14.

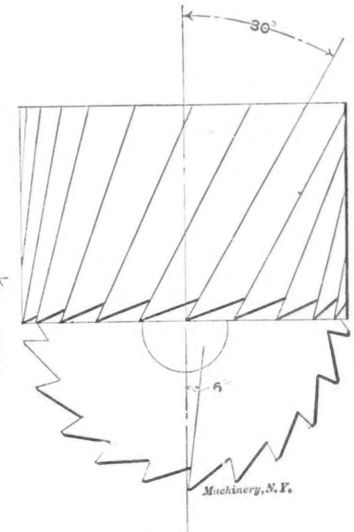


Fig. 15.

cutters of this kind when run upon strong, well-built machines are capable of taking a very heavy cut with a comparatively small expenditure of power.

A few words should also be said regarding the screw shape or longitudinal pitch of the teeth. The twist of the teeth is a necessity, to insure that the whole of the work shall not, at any instant, be thrown entirely upon one tooth, and that the cut shall be a drawing one so as to clear itself well. A diamond-shaped cutting edge is a necessity. In ordinary cylindrical milling cutters the cutting edge of the tooth usually stands at an angle of from 15 to 20 degrees with the center line; and it is, furthermore, immaterial whether it leads to the right or the left. In vertical- and side-cutting millers, such as bar cutters used for profiling, that twist, on the other hand, should be from left to right when looked at from above, if the cutter is to be used in a hole; since a left-handed twist would tend to carry the chip downward, and also force the piece being operated upon down against the table or platen. Bar cutters, which also work at the ends, as well as the regular end mills, must have teeth leading to the right, and it is especially necessary that the rake or cutting angle of these end cutters should be quite blunt. For bar cutters working on the sides only, the inclination of the cutting edge to the axis of the cutter may be made larger, and rise to from 30 to 40 degrees; which, especially on wrought iron, gives a marked advantage in cutting. In the case of end cutters this angle should not be more than 20 degrees, else the teeth at the end will be made too sharp, as in Fig. 15, and thus be too easily broken; whence the twist angle of the cutting edge which becomes the rake angle of the end teeth should be limited to 20 degrees at the highest, instead of the 30 degrees previously recommended.

It remains, now, to say a few words regarding the hardening of milling cutters, a subject which has already been frequently

discussed. For the machinist in small shops, where a special hardening plant is not provided and where the milling cutters must be hardened in the shop smithy, a few practical suggestions will not be out of place. It is, of course, self-evident to the veriest tyro of a machinist that only the very best of steel should be used for milling cutters. This necessitates a very careful manipulation in itself, aside from the dangers to which the steel is subjected by the many forms into which it may be put. In order to avoid internal stresses of the metal, milling cutters ought, under all circumstances, after being formed and before hardening, to be heated once to a red heat. This heating can be done in an oven, or, in the absence of this, in a plate metal box or piece of pipe in which it is packed in charcoal. The whole may then be raised to the hardening temperature of from 1,600 to 1,900 degrees F. in an open fire and afterward left to cool either in the oven or box. The heating for hardening can also be done in a closed box when no lead bath or muffle-furnace is available. In order to prevent the slightest particle of oxidation it will be well to coat the cutter, before heating with a layer about 1-16 inch thick of heavy soft soap. The temperature of the hardening water should under no circumstances be less than 70 degrees F. A mixture of 3 pounds of soft soap and 1 quart of muriatic acid in 25 gallons of hard water, will materially assist in the hardening, especially by delaying the cooling of the sharp edges of the teeth somewhat and thus lessening the internal tension, without acting in any way prejudicially to the hardening.

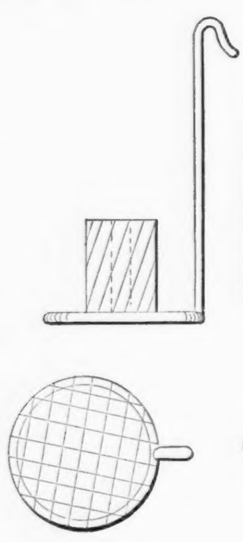


Fig. 16.

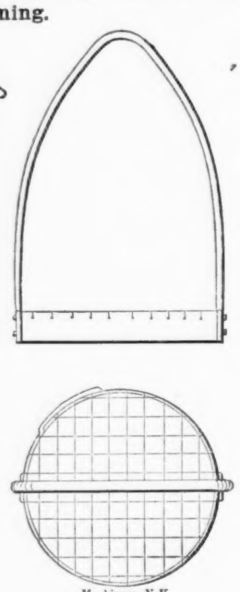


Fig. 17.

Figs. 16 and 17 illustrate a very simple and effective apparatus for submerging milling cutters in the hardening bath. Fig. 16 is intended for use with small cutters and consists of a ring with a stem and hook, and is made from a piece of ½-inch or ⅝-inch round iron. The ring is fitted with a net made of about 1-16-inch wire, so as to form a sort of coarse-meshed sieve. The heated cutter is placed upon this and slowly submerged, care being taken to always hold it vertically and then to move it about beneath the surface until the hissing can no longer be heard, when the apparatus may be suspended from its hook and left until the piece is thoroughly cooled. The wire mesh gives the water access to the bore in the piece as well as to all portions of the teeth. End millers should be placed upon the netting with the teeth uppermost, so that the thin portions may be cooled last and be fixed. Otherwise there will be danger of cracking. Fig. 17 is a similar arrangement for large and heavy cutters, which a man could not readily handle alone. The ring may be made of band iron from ⅛ inch to 3-16 inch thick and about 2 inches wide, with holes for the fastenings of the wires. The handle made of round iron is fastened to the ring with two rivets on each side. For submerging heavy cutters a bar may be passed through the handle and the whole manipulated by a man at each end. While the hardening is being done, the room should be free from drafts, and glaring daylight or bright sunshine should be deadened by painting the windows or covering them with curtains.

A milling cutter, in unskillful hands, can be ruined in a few minutes by a workman who does not understand that everything depends upon deliberation and care. Proper manipulation on the machine is therefore as essential as the proper shape and preparation. A whole chapter could well be written regarding the use of cutters in the milling machine, but the limitations of space forbid and we will confine ourselves to a few words. The speed of cutting, the feed and the depth of the cut must be governed by the material, the character of the cutter, and especially the character of the work and the shape of the piece. The speed of the cutter is alone dependent on the type of cutter, the feed and the depth of the cut. It is customary in cases of doubt to run the cutter at a certain given speed and then crowd the feed until the limits of heating are reached, or up to the strength of the machine and the resistance of the material.

The following speeds, however, will be found to be very satisfactory:

For cast iron: roughing, 35 feet per minute; finishing, 45 feet. For wrought iron with water cooling: roughing, 40 feet; finishing, 65 feet. For cast steel with water cooling: roughing, 45 feet; finishing, 60 feet. For bronze bearings: roughing, 75 feet; finishing, 100 feet.

With star-shaped cutters whose sharp edges are easily broken, somewhat lower speeds than these must be used, and the rate of feed per revolution must be reduced also. G. L. F.

THE TRANSITION PERIOD IN MACHINERY.

Extract from Address by Mr John R. Freeman at the Case School of Applied Science, May 11, 1904.

This is a transition period, and never was there such opportunity for the trained engineer. Mechanical production must supply the natural increase due to the growth in population, and replace machines worn out by service, and even new machines by something newer. Here in Cleveland your horse cars were not worn out when the cable car replaced them, your cable railways were not worn out when the electric car came in. Not only the equipment, but the shop that makes it, must largely go into scrap. Two or three years ago one of the leading engine builders of the world began on new shops in a city on the Great Lakes, the largest of their kind, designed for building engines of the most massive type. Hundreds of thousands of dollars were expended on these shops and their heavy machine tools, but before these shops were occupied, customers were inquiring, not for engines but for steam turbines. The leading pump builder of America began two years ago on new shops near New York, these also to be the largest in the world; the plans had been matured by years of study for building pumping engines of the ordinary reciprocating type. Before these shops are ready for occupancy the old and simple and inefficient type of centrifugal pump is suddenly so improved as to threaten a revolution which may profoundly change the type of shop equipment demanded. A maker of valves and fittings, a concern which has kept steadily up-to-date for more than a quarter of a century, started, about two years ago, to supply its expanding trade by a factory on the shores of Long Island Sound, designed to employ at first 2,000 and later 4,000 men. The plans were matured with rare care and judgment. First, their man of greatest skill in shop methods plans for his various machines and lays out his floor space. Next, the skilled mill engineer makes plans to house that floor space in. Next, an architect, of national reputation for his inborn sense of beautiful form and graceful line, models the outlines of exterior wall and windows and roof. Machine tools of latest design had been purchased, apparently everything had been provided for, when, just as the roofs are on, the successful demonstration of a new kind of tool steel, which permits of far deeper and more rapid cuts, calls a halt and requires a radical change.

* * *

The 15,000-ton battleship, *New Jersey*, was launched from the Fore River shipyard at Quincy, Mass., November 10. The *New Jersey* is one of five similar vessels which were authorized by act of Congress in 1899 and 1900, and has one feature of design in common with the *Kearsarge* and *Kentucky*, four of her 8-inch guns being in superimposed turrets. She will be propelled by two four-cylinder triple-expansion engines of 19,000 indicated horse power at a speed of nineteen knots.

ON THE SHAPE OF ROLLS FOR CYLINDER CAMS.

R. E. FLANDERS.

The grooves and rolls for cylindrical cams are made in various ways, more or less suitable for the work to be done. The writer had occasion, a short time ago, to give a little thought to this matter, with the following results:

Fig. 1 shows a straight roll and groove, Fig. 2 a roll with a rounded surface in a straight sided groove, and Fig. 3 a beveled roll and groove. In Fig. 1 the action of the roll is faulty, because of the varying surface speed of the cam at the top and bottom of the groove, due to its varying radial distance from the center line. This causes excessive wear and friction, especially in a quick running cam with steep pitches. For such cases, if the duty is light, the arrangement shown in Fig. 2 is better, as the roll has but a very small bearing surface, and is thus unaffected by a varying radial distance. For heavy work, however, the small bearing area is quickly worn down, and the roll presses a groove into the side of the cam as well, destroying the accuracy of the movement, and allowing a great amount of backlash.

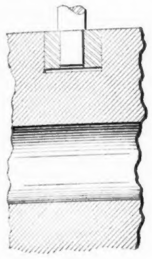


Fig. 1.

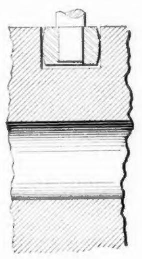


Fig. 2.

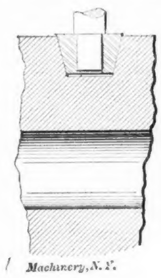


Fig. 3.

In Fig. 3 the conical shape is given to the roll with the idea of giving it a true rolling action in the groove. In most cases which the writer has noticed, the lines of the sides of the roll appear to converge on the center line of the cam, as shown in the figure. If the groove were a plain circumferential one, it would give a perfect action, like that of the pitch cones of two bevel gears rolling on each other. If the motion were in a line with the axis of the cam, without any circular movement, conditions would be perfect in Fig. 1. It is evident that in intermediate conditions, the groove must be given a shape intermediate between the two. In many cams of this variety the heavy duty comes on a section of the cam which is of nearly even pitch and of considerable length. In such a case it is best to proportion the shape of the roll to work correctly during the important part of the cycle, letting it go as it will at other times.

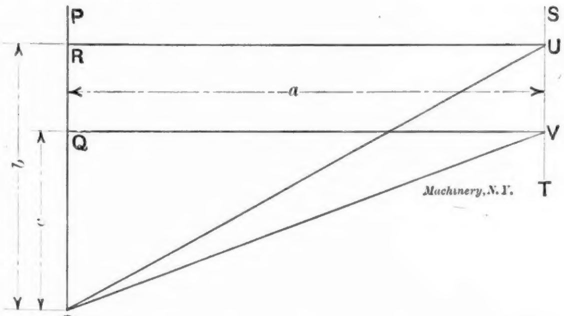


Fig. 4. Diagram showing Method of Finding the Shape of Cam Rolls.

In Fig. 4, *b* is the circumferential distance on the surface of the cam, which includes the movement we desire to fit the roll to. The throw of the cam for this circumferential movement is *a*. Line *OU* will then be a development of the movement of the cam roll during the given part of the cycle, and *c* is the movement corresponding to *b*, but on a circle whose diameter is that of the cam at the bottom of the groove. With the same throw *a* as before, the line *OV* will be a development of the cam at the bottom of the groove. *OU* then is the length of the helix traveled by the top of the roll, while *OV* is the amount of travel at the bottom of the groove. If then the top width and the bottom width of the groove be made proportional to *OU* and *OV*, the shape will be suitable to give the result we are seeking.

RALPH E. FLANDERS was born at Barnet, Vermont, September 28, 1880. His education includes four years in high school, and he served his apprenticeship in the works of Brown & Sharpe Mfg. Co., Providence, R. I. He has since worked for the Taft-Peirce Mfg. Co., Flather & Co., and the International Paper Box Machine Co. Mr. Flanders has worked as apprentice, journeyman, draftsman and designer of tools and methods of manufacture. His specialty is the design of automatic machinery for light and medium weight manufacture.

* * *

A SYSTEM OF DRILL JIGS FOR ROUGH CASTINGS.

H. J. BACHMANN.

H. J. Bachmann.

The recent contributions to MACHINERY in reference to drill jigs are interesting, but there is one type of jig that has not been described. It is an old idea in a new form and it has proven itself immensely profitable wherever employed.

Herewith are given a few sketches and a description of two jigs for drilling castings that have not been previously machined, *i. e.*, are just as they come from the foundry. It is not very difficult to design a jig when there is some part of the casting finished to size, but when there is practically nothing to start from, it becomes quite a serious matter. If we are to judge from the number of discarded jigs in the shops it seems that quite a few toolmakers have "fallen down" on this problem.

The principal feature of these jigs is, of course, the screw bushings, two of which are shown enlarged in Figs. 3 and 4. By screwing down on the bushing the casting is clamped between the screw bushing and the plain bushing shown in the bottom of the jigs. Thus it will be seen that they perform the double function of locating the hole and also holding the casting securely in its proper position in the jig. When only one end of the boss is accessible the plain bushing cannot be used, and other means must be devised to back up the thrust of the screw bushing.

Being movable they will take care of any reasonable variation in the size of the castings and also insure that the hole shall be drilled in the center of the boss. This latter condition is very desirable in work of this kind, for the sake of appearance and strength. In this form they are rendered applicable to all forms of castings having any kind of a circular projection or boss over which the bushings may be fitted, as shown in the cuts.

When headless bushings are necessary (as on both ends of the larger jig, Figs. 5, 6 and 7) they are tightened down with a spanner, whereas a plain drill rod pin is sufficient for the other. When both ends of the boss are held by bushings the holes to receive these bushings must be in line and when they are so aligned it is impossible for the hole to come out of center on either end of the boss. The simplest and safest way to align these holes is to run a single-pointed boring bar through the screw bushing into the bottom of the jig after the screw bushing has been fitted to the jig, the shank of the boring bar, of course, to be a good fit in the hole of the screw bushing which has been previously lapped to size.

On the larger sizes of bushings it has been found advantageous to use a good quality of machine steel, case-hardened and having a smaller tool steel bushing inserted in the center. When made of all tool steel the distortion caused by hardening is too great to allow a good fit, which is essential on the threaded portion.

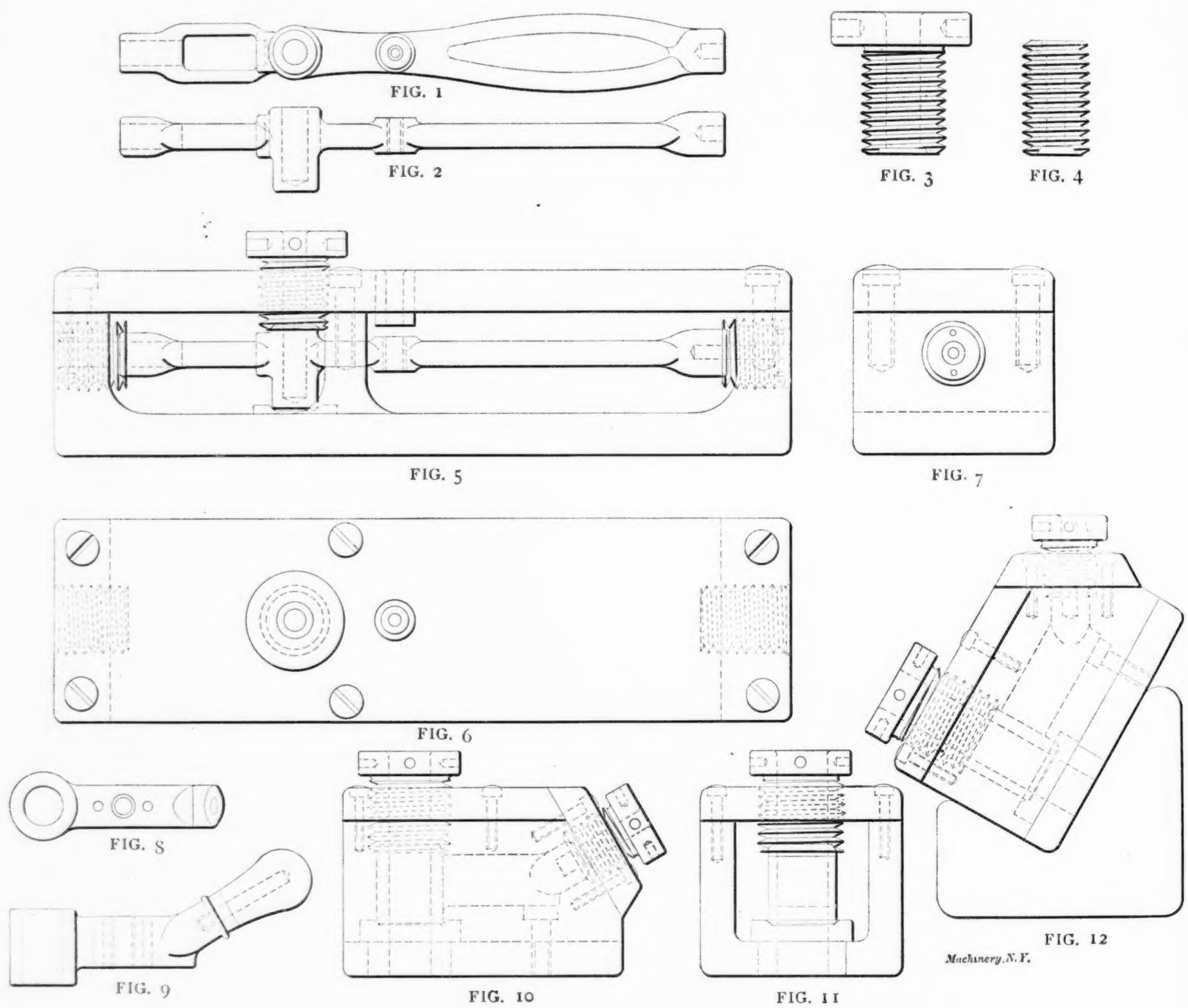
The bodies of the jigs are made of cast iron, cradle-shaped and cut out where possible to facilitate cleaning. The covers which hold the screw bushings are of machine steel, held in place by means of filister head screws and dowels.

HENRY J. BACHMANN was born in Burschal Baden, Germany, March 28, 1880. He took a course in Pratt's Institute, Brooklyn and served an apprenticeship with the Brass Goods Mfg. Co. of that city. He has since worked for the Neptune Meter Co., General Incandescent Arc Light Co., F. A. Errington and the Cutler-Hammer Mfg. Co. He is a toolmaker and his specialty is tools for brass working. Mr. Bachmann has been an occasional contributor to MACHINERY for a number of years.

The larger jig, Figs. 5, 6 and 7, was designed for drilling the breast drill frame shown in Figs. 1 and 2. The casting is clamped by the large bushing first and then the smaller bushings on the end are brought up just tight enough to obviate any spring in the casting. There are two holes in this frame which must be reamed square with each other. After trying unsuccessfully to ream the holes by hand after drilling in the jig the holes were reamed in the jig as follows: The hole in the bushing was made the exact size of the hole to be reamed in the casting. A drill of this size was used to spot the hole, following with a reamer drill and lastly the rose reamer, making in every respect a satisfactory job.

The smaller jig, Figs. 10, 11 and 12, designed for the simple lever shown in Figs. 8 and 9, presents no difficulties beyond the drilling and tapping of the hole for the wooden handle at an angle of 30 degrees, and the adjustable stud screwed into the bottom of the jig to resist the pressure of the bushing. In this jig it is also necessary to clamp the larger boss first, so that when the smaller bushing is tightened there will be no tendency to displace the casting. The same procedure was followed in the case of the tapped hole as in the case of the reamed hole, namely: full size drill to spot, tap drill and then the tap itself. This latter was operated by means of a tapping attachment with friction chuck. The advantage over tapping by hand was evident because every handle fitted the lever just as shown in the sketch, adding greatly to the appearance of the finished article. The method of tilting the jig by means of the 60-degree angle block, Fig. 12, is open to criticism, but inasmuch as it was the simplest way, it was adopted. It is hardly necessary to say that these jigs are most profitably employed in connection with a multiple-spindle drill press, but even with a single spindle press they will show a saving over some ancient devices.

There is one thing that is generally overlooked in the construction of jigs and that reminds the writer of a very conspicuous sign in a large patternmaking shop—"Round all edges and fillet all corners"—should apply to the toolmaker as well as the patternmaker, for if he does not take the trouble to finish his work the boys in the shop will finish it for him in a way he won't like.



System of Drill Jigs for Rough Castings.

* * *

NOTES ON TOOLMAKING.

FRANK E. SHAILOR.

A good rule to follow when planing work is: "Plane the widest surface first." For instance, a die block is to be planed all over. The wide side is done first, next one edge, the block being positioned by the wide side just planed, bearing against the solid jaw of vise; then the block is inverted and the other edge planed, it being still positioned by the planed wide side against the solid jaw. We now have three planed surfaces to position the block for the last wide side. If the edges are planed first, as is customary with a great many machinists, it is obvious that the edges were positioned by unplaned, and therefore untrue, surfaces, hence they will not be parallel with each other. Moreover, the edges do not furnish ample bearing to properly position the block for planing the wide side at right angles.

When planing any work where absolute parallelism is required, never depend on the vise or bed of the machine unless the bed has been very recently trued up. A very good way to accurately machine work and to overcome the necessity of truing the bed, is to machine the piece all over to within a few hundredths of size, and then grip a piece of scrap steel or cast iron in the vise, or on the bed of the planer (or surface grinder) and carefully machine the surface. We now have a surface true with the crosshead of the planer or emery wheel spindle of the grinder. The piece to be finished is in

turn waxed to said true surface and with a keen cutting tool or emery wheel the piece can be accurately brought to size.

A wax suitable for this purpose is composed of 7 parts beeswax, 2 parts rosin, and 1 part shoemaker's wax melted together and thoroughly mixed. Just before the wax is cold, form into conveniently shaped sticks. The wax is applied around the edges of the work with a warm soldering iron, but care must be taken that no grit or wax gets under the piece to be machined. The wax does not become brittle so it can easily be removed with a copper scraper and used over and over. It is

Fig. 1 Diamond lap

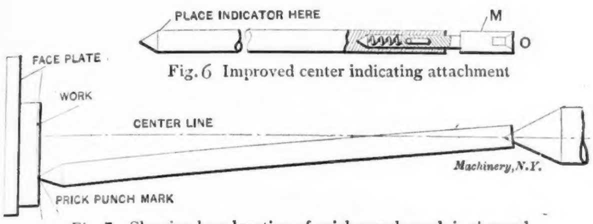


Fig. 6 Improved center indicating attachment

Fig. 7 Showing how location of prick punch mark is changed, when using solid bar

Notes on Toolmaking.

understood, of course, that "cut-meter" speeds cannot be employed when using wax for holding work. Light chips must be taken, especially on the surface grinder, as heavy chips would warm the work and cause the wax to melt. The holding qualities of this wax are such that the bed of a No. 2, B. & S. surface grinder can be moved back and forth by means of a piece of steel 3 inches square waxed to the bed. For holding thin work that must be straight when finished, the

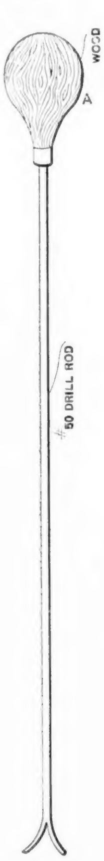


Fig. 2.

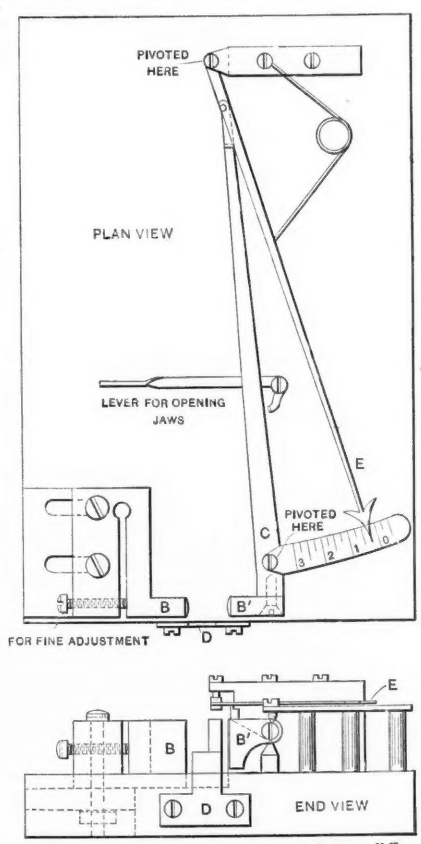


Fig. 3.

wax will be found superior to the magnetic chuck, for the chuck exerts such a tremendous pull that if a piece of work is slightly sprung it will straighten against the magnetic face and after the piece has been ground and removed from the chuck, it will be found to have assumed its original curved form.

Grinding with Diamond Dust.

Diamond dust of all grades is an indispensable article in the up-to-date toolroom. To cite the many uses to which diamond dust can be profitably applied would require considerable space, and so only a few will be mentioned. It is extremely valuable in grinding small spring chucks having holes, say 0.060 inch in diameter. It is impossible to use an emery wheel in a hole of such diameter and unless the hole is ground the chuck will not, as a rule, run true. By charging the lap, Fig. 1, uniformly with diamond dust, a very small hole can be ground as nicely as though it were a 2-inch hole ground by an emery wheel. The lap is charged with diamond dust by rolling it between two hardened surfaces, but the dust should never be *pounded* into the lap. To obtain the best results the lap must run true and cut all around, but this is not possible if the dust is pounded in the lap, for the hammer blows produce minute flat spots, so that only the corners or high spots touch the work. Diamond dust does not spark and it is an easy matter to crowd the lap and strip some of the dust. To overcome this possibility the "harker" shown in Fig. 2 is brought into play. The forked end is placed against

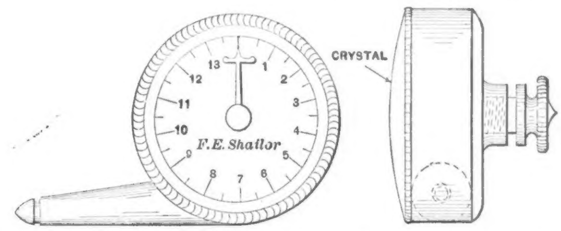


Fig. 4 Indicator for general work, assembled Multiplies 100 times

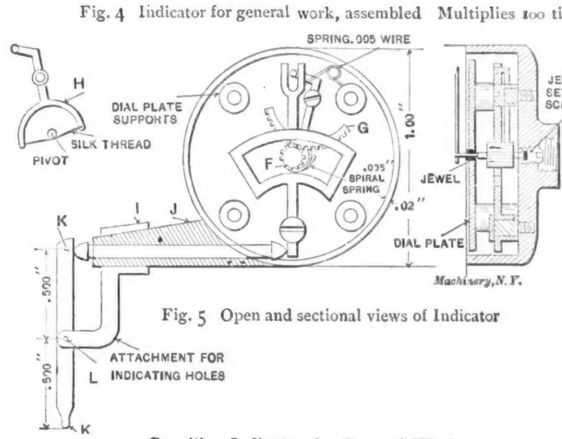


Fig. 5 Open and sectional views of Indicator

Sensitive Indicator for General Work.

some stationary part of the grinder spindle, and end, *A*, placed in the ear. The movement when the lap touches the work is readily noted as the slightest sound magnified many times vibrates along the rod. The harker is nothing new, for our fathers were content to use an ordinary file in place of the more elaborate tool shown at Fig. 2.

One thing that must be closely watched when using diamond dust for grinding is that the lap does not become dry, but is kept moistened with a thin lubricant. Kerosene is excellent for this purpose. Soft work should never be ground with diamond dust as the dust will leave the lap and charge the work. The writer has often made small gages, both plug and ring, by roughly grinding first with No. 1 diamond, and then substituting for the lap one containing No. 5 or No. 6 diamond (which is very fine), lapping the gage to size at the same setting.

In grinding a plug gage much difficulty is experienced when calipering to find if the gage is perfectly straight. No matter how skillful a mechanic may be in using the micrometer, he is sure to apply uneven tension on work when measuring, and as 0.0001 inch one way or the other ruins a plug gage for accuracy, the simple little tool shown in Fig. 3 will be found of exceptional value in determining the straightness of a gage, though not the size unless it is set with a standard. The gage here shown multiplies errors 200 times. The jaws, *B*, *B'*, are hardened, ground and lapped. Jaw *B* is adjustable, while the other jaw is movable and connected to indicator point, *C*. An adjustable stop, *D*, is provided for the work to rest on, so that the jaws will be squarely in contact with the work. If three gages are to be made, as is customary, the indicating instrument will be found valuable in making them exactly the same size. When one is finished satisfactorily,

set the gage between the jaws of the indicator and note the graduation recorded by pointer, *E*. Since the indicator reading is 200 times greater than the actual error, it will now be easy to make the other two gages as nearly alike as it is possible to get them. It has often occurred to me that this style of instrument would make an excellent universal gage for pieces of work ordinarily measured with a snap gage, having a limit of 0.0001 inch or 0.0002 inch. All that would be necessary to make one indicator cover a large field of work, would be to retain a standard of each piece to be gaged, and set one indicator to said standard. An indicator of this denecessary to make one indicator cover a large field of work, each year for the reason that 0.0001 and often 0.00001 inch prevents a piece entering the ordinary snap or ring gage and it is thrown out. On the other hand a piece enters the gage and is accepted, but said piece is often as much below size as the piece thrown away was above. With the inspector it is a matter of go in or not go in. If it goes in it is "all right," if it does not go in, it is "scrap."

Fig. 4 shows another style of indicator that I designed and built for my own use. The dimensions are given here for the benefit of those who are occasionally inclined to do "Government work." This indicator is very sensitive and can be used on locomotive building, thus covering the entire field. The objection to most indicators now on the market is that they are not sensitive enough for small work, such as watch or instrument pivots, and will cause said pivot to "spring" before sufficient pressure is applied to make the indicator needle register. The indicator shown at Fig. 4 can be made either with the pinion, *F*, and segment of gear, *G*, or as shown at *H*. The lever, *H*, contains a silk cord wound once around the pivot upon which the pointer is fastened. If the silk thread is used it should be soaked in melted beeswax to prevent the fuzz or fringe fraying out under constant use. In Fig. 5 is shown an attachment for indicating holes. *I* represents a sleeve having a tapered hole which fits the taper, *J*. The contact points, *K K*, are equidistant from center, *L*.

Fig. 6 shows an improved centering attachment, the improvement being the spring end, *M*. If the bar were solid and the pointed end were placed in the prick punch mark of the work on the faceplate, with the tail center placed in end, *O*, it is obvious that the prick punch mark would be distorted and its position changed when knocking the work to bring the prick punch mark central with the spindle. By use of the spring end on the bar in sketch, this difficulty is overcome since the spring compresses before the point of the bar distorts the prick punch mark. The reader probably knows that it is a disagreeable, uncertain job to indicate work with the old-fashioned so-called "wiggler." The vibration of the shop causes the needle point to constantly tremble, it is difficult to ascertain the "high point" of the needle when rotating the faceplate, and the "wiggler" seldom multiplies over 15 times. When using an indicator in connection with the bar shown at Fig. 6 for indicating a prick punch mark or hole, all that is necessary is to note how many graduations the needle has traversed and knock the work so that the needle will go back one-half that amount, and there you are almost at the first rap. In my opinion it is poor policy to use a prick punch mark for determining the exact center of a piece of work. To grind a button to some given size, fasten it the proper distance from the edges of the work, and then to indicate the button is a much more accurate way, for we have no assurance that the prick punch was driven in exactly where it should have been. True it may be very close, but the day of "somewhere near" has passed.

* * *

TABLE OF SPUR GEAR TEETH GIVING DIAMETRAL PITCH.

L. S. BURBANK.

There are plenty of good formulas giving the shape of gear teeth, size of blanks, etc., but I have often wished that there was a table of gear teeth giving the proper diametral pitch and face of teeth under various conditions so one might have it before him to see at a glance whether or not the ratio of teeth desired would admit of sufficient tooth-strength. Figuring the strength of gear teeth is, in many instances, somewhat unsatisfactory because the bother of choosing and applying one of the many varied and more or less complicated formulas does not justify the time spent, especially as the size of teeth is so often and so largely modified by the velocity ratio that to keep within a safe strength is often the main object. But to guess at it pure and simple is going altogether too much in the dark, although I have no doubt that more gear teeth are guessed at, *as to strength*, than are figured, if the truth could be known.

Why not have a table giving the diametral pitch directly for all gear teeth working within certain practical limits? Then all that need be done is to ascertain the tooth speed and the force or horse power, under which it works, and, from the table, read at once the allowable diametral pitch for an assumed proportional tooth-face, provided for in the table; the result, together with the velocity ratio already known, gives all the data necessary to make a drawing or sketch. Let us see what can be had for a table:

In Kent's Mechanical Engineer's Pocketbook under the heading of "Gearing" may be found an interesting comparison of some gear tooth formulas by various authors, made for the purpose of showing the variation in results, but favors, with good reasons, an empirical formula by Mr. Wilfred Lewis. This formula gives $W = s\,p\,f\,y$, where W is the load, in pounds, transmitted by the teeth; s, the safe working stress of the material; p, the circular pitch; f, the face of tooth, in inches; and y, is a factor depending upon the form, and number of teeth, and whose value for different cases is given in a table. The value for this factor, y, for a cycloidal tooth or a 15-degree involute tooth, which latter is the one most commonly in use, is given as ranging from 0.067, for a pinion of 12 teeth, to 0.124, for a rack. The working stress, s, for different speeds of cast iron teeth, is given as ranging from 8,000 pounds for a tooth speed of 100 feet or less per minute, to 1,700 pounds for a tooth speed of 2,400 feet. The gradation is given by a table as follows;

Speed.	100 feet or less.	200	300	600	900	1200	1800	2400
s	8000 lbs.	6000	4800	4000	3000	2400	2000	1700

If, in the above formula, the variable quantities could be reduced to two in number and the circular pitch expressed as diametral pitch, a very convenient table, such as I have mentioned, could be arranged: Suppose we let p_1 = the diametral pitch then $p = \frac{\pi}{p_1}$. Suppose also we assume the width of face, f, to be 8 divided by the diametral pitch; or $f = \frac{8}{p_1}$. This gives a very good proportion for the face and one easily determined afterward from the table.

$$\text{Then } p\,f = \frac{\pi}{p_1} \times \frac{8}{p_1} = \frac{8\,\pi}{p_1^2}$$

Substituting this value in the original formula we get

$$W = \frac{s\,y\,8\,\pi}{p_1^2}$$

from which

$$p_1 = \sqrt{\frac{s\,y\,8\,\pi}{W}}$$

Suppose now, as the original formula can be only approximately correct, that we strike an average for the factor, y, as between 0.067 and 0.124, and call it 0.1. Then our formula stands

$$p_1 = \sqrt{\frac{s\,8\,\pi}{W}}$$

which we can separate into two factors and express it

$$p_1 = \sqrt{s} \times \sqrt{\frac{2.51}{W}}$$

In this formula the factor $\sqrt{s}$ contains the working stress

TABLE OF SPUR GEAR TEETH

GIVING THE

DIAMETRAL PITCH

FOR

15° INVOLUTE CAST IRON TEETH UNDER VARIOUS LOADS AND SPEEDS

THE WIDTH OF FACE BEING 8 DIVIDED BY THE PITCH AS FOUND

THE SMALL FIGURES REPRESENT THE H.P.

OCT. 18 1904 BY L.S. BURBANK

FORMULA. $W = spfy$
WHERE W = Load, equally distributed, on 1 tooth, s = safe working stress, varying with speed, from 8000 lbs. at 100 ft. or less to 1700 lbs. at 2400 ft. p = Circular pitch P = Diametral pitch f = Face and $y = .1$ Then $p = \frac{\pi}{P}$ and $f = \frac{8}{P}$ $\therefore$ $pf = \frac{8\pi}{P^2}$ and $P = \sqrt{\frac{9 \times 8\pi}{W}} = \sqrt{s} \times \sqrt{\frac{2.51}{W}}$.

GEAR TEETH

GEAR TOOTH TABLE 4 SHEETS-1 (LOAD 1 TO 7.5)

$\sqrt{s}$	Load in pounds at pitch line: 1	2	3	5	7.5	Velocity at pitch line in ft. per min.
	Diametral pitch and H.P.					
41.2	64 (.075)	48 (.15)	36 (.225)	30 (.35)	24 (.55)	2400
41.2	64 (.06)	48 (.12)	36 (.18)	30 (.3)	24 (.45)	2000
44.7	64 (.055)	48 (.11)	40 (.16)	32 (.27)	26 (.41)	1800
44.7	64 (.045)	48 (.09)	40 (.14)	32 (.23)	26 (.34)	1500
49.0	80 (.036)	64 (.072)	48 (.11)	36 (.18)	28 (.27)	1200
54.8	80 (.03)	64 (.06)	48 (.09)	40 (.15)	32 (.23)	1000
54.8	80 (.025)	64 (.05)	48 (.075)	40 (.12)	32 (.18)	800
63.3	80	64 (.036)	64 (.055)	48 (.09)	36 (.14)	600
63.3	80	64 (.03)	64 (.045)	48 (.075)	36 (.11)	500
63.3	80	64 (.025)	64 (.036)	48 (.06)	36 (.091)	400
69.2	80	80 (.018)	64 (.027)	48 (.045)	40 (.068)	300
69.2	80	80 (.015)	64 (.023)	48 (.038)	40 (.057)	250
77.5	80	80	64 (.018)	48 (.03)	48 (.045)	200
77.5	80	80	64 (.013)	48 (.023)	48 (.034)	150
89.5	80	80	64 (.009)	64 (.015)	48 (.023)	100
89.5	80	80	64 (.007)	64 (.011)	48 (.017)	75
89.5	80	80	80 (.005)	64 (.007)	48 (.011)	50
89.5	80	80	80	64 (.005)	48 (.008)	35
89.5	80	80	80 (.002)	64 (.004)	48 (.006)	25
89.5	80	80	80 (.002)	64 (.003)	48 (.004)	20
89.5	80	80	80 (.001)	64 (.002)	48 (.003)	15
99.5	80	80	80 (.001)	64 (.002)	48 (.002)	10
89.5	80	80	80 (.001)	64 (.001)	48 (.001)	6
	1.6	1.12	.915	.709	.579	$\sqrt{\frac{2.51}{W}}$

GEAR TOOTH TABLE 4 SHEETS-2 (LOAD 10 TO 50)

$\sqrt{s}$	Load in pounds at pitch line: 10	15	25	35	50	Velocity at pitch line in ft. per min.
	Diametral pitch and H.P.					
41.2	20 (.72)	16 (1.1)	13 (1.8)	11 (2.5)	10 (3.6)	2400
41.2	20 (.6)	16 (.9)	13 (1.5)	11 (2.1)	10 (3.)	2000
44.7	22 (.53)	18 (.82)	14 (1.4)	12 (1.9)	10 (2.7)	1800
44.7	22 (.45)	18 (.68)	14 (1.1)	12 (1.6)	10 (2.3)	1500
49.0	24 (36)	20 (.55)	16 (.9)	14 (1.3)	10 (1.8)	1200
54.8	28 (.3)	22 (.45)	18 (.75)	14 (1.1)	12 (1.5)	1000
54.8	28 (.25)	22 (.36)	18 (.6)	14 (.85)	12 (1.2)	800
63.3	32 (.18)	28 (.26)	20 (.45)	16 (.64)	14 (9)	600
63.3	32 (.15)	28 (.23)	20 (.30)	16 (.53)	14 (5)	500
63.3	32 (.12)	28 (.18)	20 (.3)	18 (.42)	14 (6)	400
63.2	36 (.09)	28 (.14)	22 (.23)	18 (.32)	16 (45)	300
63.2	36 (.075)	28 (.11)	22 (.19)	18 (.26)	16 (38)	250
77.5	36 (.06)	36 (.09)	24 (.15)	20 (.21)	18 (3)	200
77.5	36 (.045)	36 (068)	24 (.11)	20 (.16)	18 (23)	150
89.5	48 (03)	36 (.045)	28 (.075)	24 (.11)	20 (15)	100
89.5	48 (.023)	36 (.034)	28 (.057)	24 (.08)	20 (11)	75
89.5	48 (.015)	36 (.073)	28 (.038)	24 (.053)	20 (.073)	50
89.5	48 (.01)	36 (.016)	28 (.026)	24 (.037)	20 (.053)	35
89.5	48 (.008)	36 (011)	28 (.019)	24 (.026)	20 (038)	25
89.5	48 (.006)	36 (.009)	28 (.015)	24 (.021)	20 (03)	20
89.5	48 (.005)	36 (.007)	28 (.011)	24 (.016)	20 (.023)	15
89.5	48 (.003)	36 (.005)	28 (.007)	24 (.011)	20 (.015)	10
89.5	48 (.002)	36 (.003)	28 (.005)	24 (.006)	20 (.009)	6
	.501	409	.317	.268	224	$\sqrt{\frac{2.51}{W}}$

GEAR TOOTH TABLE 4 SHEETS-3 (LOAD 75 TO 250)

$\sqrt{s}$	Load in pounds at pitch line: 75	100	150	200	250	Velocity at pitch line in ft. per min.
	Diametral pitch and H.P.					
41.2	8 (5.5)	6 (7.3)	6 (11.)	4 (14.5)	4 (18.)	2400
41.2	8 (4.5)	6 (6.0)	6 (9.1)	4 (12.)	4 (15.)	2000
44.7	8 (4.)	7 (5.5)	6 (8.2)	5 (11.)	4 (13.6)	1800
44.7	8 (3.4)	7 (4.5)	6 (6.8)	5 (9.)	4 (11)	1500
49.0	9 (2.7)	8 (3.6)	6 (5.5)	6 (7.3)	5 (9.1)	1200
54.8	10 (2.3)	9 (3.0)	7 (4.5)	6 (6.)	6 (7.6)	1000
54.8	10 (1.8)	9 (2.4)	7 (3.6)	6 (4.8)	6 (6.1)	800
63.3	12 (1.4)	10 (1.8)	8 (2.7)	7 (3.6)	6 (4.5)	600
63.3	12 (1.1)	10 (1.5)	8 (2.3)	7 (3.)	6 (3.8)	500
63.3	12 (.9)	10 (1.2)	8 (1.8)	7 (2.4)	6 (3.0)	400
69.2	12 (.68)	12 (.9)	9 (1.4)	8 (1.8)	7 (2.3)	300
69.2	12 (.57)	12 (.75)	9 (1.1)	8 (1.5)	7 (1.9)	200
77.5	14 (.45)	12 (.6)	10 (.9)	8 (1.2)	8 (1.5)	200
77.5	14 (.34)	12 (.45)	10 (.68)	8 (.9)	8 (1.1)	150
89.5	16 (.23)	14 (.3)	12 (.45)	10 (.6)	9 (.76)	00
89.5	16 (.17)	14 (.23)	12 (.34)	10 (.43)	9 (.57)	75
89.5	16 (.11)	14 (.15)	12 (.23)	10 (.3)	9 (.38)	50
89.5	16 (.08)	14 (.11)	12 (.16)	10 (.21)	9 (.26)	35
89.5	16 (.057)	14 (.075)	12 (.11)	10 (.15)	9 (.19)	25
89.5	16 (.045)	14 (.06)	12 (.09)	10 (.12)	9 (.15)	20
89.5	16 (.034)	14 (.045)	12 (.068)	10 (.09)	9 (.11)	15
89.5	16 (.023)	14 (.03)	12 (.045)	10 (.06)	9 (.076)	10
89.5	16 (.014)	14 (.018)	12 (.027)	10 (.036)	9 (.045)	6
	.183	.158	.129	.112	.100	$\sqrt{\frac{2.51}{W}}$

GEAR TOOTH TABLE 4 SHEETS-4 (LOAD 300 TO 1000)

$\sqrt{s}$	Load in pounds at pitch line: 300	400	500	750	1000	Velocity at pitch line in ft. per min.
	Diametral pitch and H.P.					
41.2	4 (23.8)	3 (23.)	3 (36.4)	2 (54.5)	2 (73.)	2400
41.2	4 (18.)	3 (24.2)	3 (30.3)	2 (45.5)	2 (60.)	2000
44.7	4 (16.4)	4 (21.8)	3 (27.3)	3 (41.)	2 (55.)	1800
44.7	4 (13.6)	4 (18.2)	3 (22.7)	3 (34.)	2 (45.)	1500
49.0	4 (40.9)	4 (14.5)	3 (18.2)	3 (27.)	2 (36.)	1200
54.8	5 (9.1)	4 (12.1)	4 (15.3)	3 (23)	3 (30.)	1000
54.8	5 (7.3)	4 (9.7)	4 (12.1)	3 (18.)	3 (24.)	800
63.3	6 (5.4)	5 (7.3)	4 (9.1)	4 (14.)	3 (18.)	600
63.3	6 (4.5)	5 (6.0)	4 (7.6)	4 (11.)	3 (15.)	500
63.3	6 (3.6)	5 (4.8)	4 (6.0)	4 (9.1)	3 (12.)	400
69.2	6 (2.7)	5 (3.6)	5 (4.5)	4 (6.8)	3 (9)	300
69.2	6 (2.3)	5 (3.)	5 (3.8)	4 (5.7)	4 (7)	250
77.5	7 (1.8)	6 (2.4)	5 (3.0)	4 (4.5)	4 (6.)	200
77.5	7 (1.4)	6 (1.8)	5 (2.3)	4 (3.4)	4 (4.5)	150
89.5	8 (.91)	7 (1.2)	6 (.35)	5 (2.3)	4 (3.)	100
89.5	8 (.64)	7 (.91)	6 (1.1)	5 (1.7)	4 (2.3)	75
89.5	8 (.45)	7 (.6)	6 (76)	5 (1.1)	4 (1.5)	50
89.5	8 (.32)	7 (.42)	6 (53)	5 (.8)	4 (1.1)	35
89.5	8 (.23)	7 (.3)	6 (38)	5 (.57)	4 (.75)	25
89.5	8 (.18)	7 (.24)	6 (30)	5 (.45)	4 (.6)	20
89.5	8 (.14)	7 (.18)	6 (23)	5 (.34)	4 (.45)	15
89.5	8 (.09)	7 (.12)	6 (.15)	5 (.23)	4 (.3)	10
89.5	8 (.05)	7 (.072)	6 (.09)	5 (.14)	4 (.18)	6
	.0915	.0792	.0708	.0579	.0501	$\sqrt{\frac{2.51}{W}}$

These Tables are Reproduced in their Original Form as presenting a good Example of Compilation of Engineering Data in Convenient Shape for Ready Reference.

for tooth speeds and the factor $\sqrt{\frac{2.51}{W}}$ contains the load on the tooth.

Now we can easily arrange a vertical column from the small preceding table, containing a series of values for $\sqrt{s}$ covering a convenient range of tooth speeds—say, from 6 to 2,400 feet per minute—and likewise a horizontal row containing a series of values for $\sqrt{\frac{2.51}{W}}$ covering a convenient range of loads say, from 1 to 1,000 pounds.

Then from the products of these two sets of figures we can compile the desired table of diametral pitches. As these factors are preliminary, they need not necessarily appear in a working table. As the products of $\sqrt{s}$ and $\sqrt{\frac{2.51}{W}}$ (the loads and velocities) divided by 33,000 give the horse powers, I have included these (in the small figures) because of their addition to the value and convenience of the table. Some of these H. P. values are pretty small, to be sure, but none the less instructive.

Let us now take an example: Suppose we were designing a machine in which a belt wheel, running at 200 R. P. M., is to drive a pinion shaft whose pinion meshes with a gear running at 25 R. P. M., and we know, either by calculation or experiment, that the force, or load, on one of these gear teeth is 300 pounds. What are the proper dimensions of the gear blanks and what size pulley should we use, the distance between shafts being 18 inches?

The velocity ratio is 200 to 25 or 8 to 1. The sum of these ratio terms is 9. The diameter of the gear, on the pitch line would be $2 \times \frac{8}{9} \times 18 = 32$ inches. Its tooth velocity would be

$$\frac{32 \times 3.14 \times 200}{12} = 1{,}675, \text{ say } 1{,}500 \text{ feet per minute.}$$

The load we already know to be 300 pounds. Now, from the table we read at once the diametral pitch to be 4, and incidentally we see the horse power to be 13.6, say 14. The width of face is $8 \div 4 = 2$ inches and the outside diameter of the blank, by the well known rule, is $32 + 2/4 = 32\frac{1}{2}$ inches. The pinion blank is $4\frac{1}{2}$ inches diameter by 2-inch, say $2\frac{1}{4}$-inch face. The number of teeth in the gears are, of course, readily calculated, knowing the diameters and the diametral pitch. For the dimensions of the pulley we have given in the table the H. P. and we have simply to apply some belt formula such as H. P. $= \frac{DRW}{2750}$ and, if we choose a 6-inch belt, our pulley is 32 inches diameter. The horse power, as given, is equally convenient in calculating sizes of the shafts, that is to say, the bores of the gears.

The table will be found convenient also in modifying the original tooth face in cases where it is desirable to use a different pitch from that given in the table. Where the pitch is chosen in the same horizontal line in which the original is found, it is simply necessary to multiply the tooth face, derived from the original pitch, by the ratio of horse powers corresponding to the two pitches; the original horse power being the numerator. The resulting tooth-face gives a strength equal to the original tooth.

For instance, suppose, in the above 32-inch wheel, that it were desirable to use a 5 pitch instead of the 4 pitch called for; the original tooth-face is $\frac{8}{4} = 2$ inches, as above; the horse power corresponding to the original pitch 4, is 13.6 and that corresponding to 5 (in the same line) is 9; the required tooth-face, therefore, is $2 \times \frac{13.6}{9} = 3.02$ inches, say 3 inches. Where the desired pitch occurs several times in the same line, the average horse power may be taken.

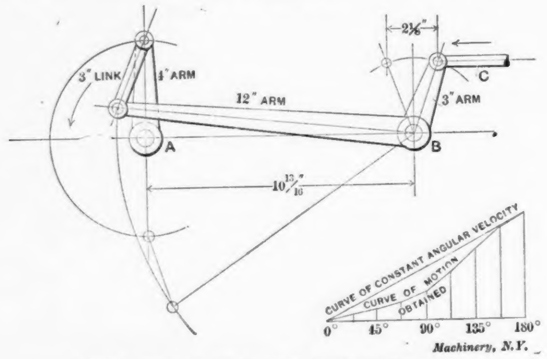
I trust that the above table will prove to be of practical value in many places.

LETTERS UPON PRACTICAL SUBJECTS.

LINK MOTION FOR ROTATING A SHAFT 180 DEGREES.

Editor MACHINERY:

We had a little problem which consisted of driving the shaft *A* through an arc of 180 degrees, or slightly over, without the use of gears, the movement to be reversible and without backlash. The driving shaft is not shown, but it operated by means of a crank, the rod *C*, shown in the sketch.



Link Motion for Rotating a Shaft 180 Degrees.

We accomplished our results as follows: A 4-inch lever arm was keyed to the end of the shaft *A*. A 3-inch link connected this lever to a 12-inch lever arm at *B*, whose center of oscillation was on the line bisecting the 180-degree arc and at a point 10 13-16 inches from *A*. The 12-inch arm is operated by a rod working on a 3-inch arm lever mounted on same shaft. The sketch shows the relative positions of the various parts after moving through the 180 degrees. The angular velocity of *A*, however, is far from constant, as may be seen from the accompanying diagram, in which the ordinates are proportional to the distance traveled by the rod *C* at the driving end. The straight line above the curve would indicate the curve for a constant angular velocity. J. D. ADAMS.

Phoenix, Ariz.

GRAPHICAL SOLUTION FOR BEAMS.

Editor MACHINERY:

In finding the modulus required in a beam to carry a given load over a certain span, the accompanying diagram has been found to be of value. To the left of the diagram will be found a column of spans in inches. Reading across the sheet we find the oblique lines for the various loads, from the intersection of which with the span line we read above or below, as the case may be, until we intercept the oblique line of the fiber stress to be employed. From the intersection thus found we read again to the right and find on that side of

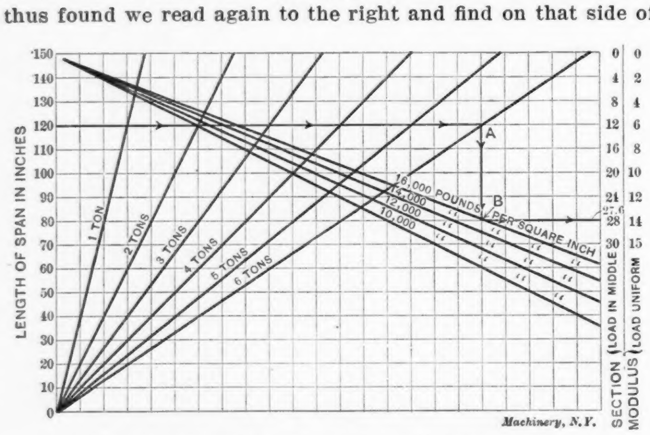


Chart for Graphical Solution of Section Modulus of Beams.

the sheet the correct section modulus to be employed for the different cases of loading as indicated. For example: What section modulus is required for a beam having a span of 120 inches and carrying a load in the center of 12,000 pounds when the fiber stress is limited to 16,000 pounds per square inch? The horizontal from 120 intersects the 6-ton or 12,000-pound diagonal at *A;* thence the vertical intersects the 16,000-pound fiber stress diagonal at *B;* and thence the horizontal gives the reading 27.6 in the first column at the right. It can readily be seen that in like manner a column of section moduli for the cantilever may also be added.

WALTER RAUTENSTRAUCH.

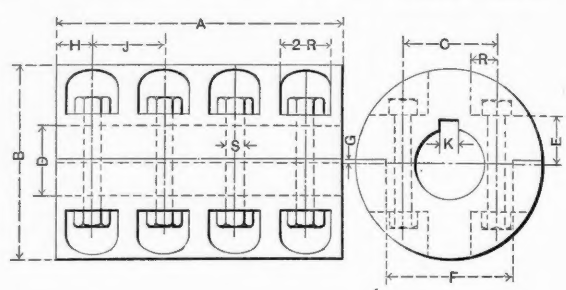
Sibley College, Ithaca, N. Y.

THE ADVANTAGE OF THE CLAMP COUPLING IN CEMENT MILLS.

Editor MACHINERY:

In mills where dusty or gritty products are handled machinery wears out rapidly and has to be replaced very frequently. In replacing such machinery it is very often desirable to do it with machinery of a later and improved pattern. This necessitates a continual taking down and putting up of shafting for the purpose of shifting or removing pulleys, gears and clutches. With the usual form of flange coupling this is quite a job as the couplings are hard to remove from the shafts and after they have been replaced and keyed on, the shaft has to be put in a lathe and the coupling squared up.

In our mill we frequently ran from one week's end to another with scarcely a stop, so the time left for repairs was very limited. We found the style of coupling shown with



D	A	B	C	E	F	G	H	J	K	R	S	WEIGHT LBS.
1 7/16	6	4 1/4	2 1/2	1 1/8	3 5/8	1/8	1 1/2		5/16	15/16	5/8	19.89
1 11/16	7	4 7/8	3	1 3/16	4	3/16	1 3/4		7/16	1 1/16	3/4	30.24
1 15/16	8	5 1/2	3 1/4	1 3/8	4 1/4	1/4	2		7/16	1 1/16	3/4	43.95
2 3/16	9	6 1/8	3 1/2	1 1/2	4 1/2	1/4	2 1/4		9/16	1 1/16	3/4	66.09
2 7/16	10	6 3/4	3 7/8	1 5/8	5	1/4	2 1/2		9/16	1 3/16	7/8	82.15
2 11/16	11	7 3/8	4	1 7/8	5	1/4	1 3/8	2 3/4	9/16	1 1/16	3/4	107.55
2 15/16	12	8	4 1/4	2	5 1/4	1/4	1 1/2	3	11/16	1 1/16	3/4	121.84
3 3/16	13	8 5/8	4 1/2	2 1/8	5 1/2	1/4	1 5/8	3 1/4	11/16	1 1/16	3/4	168.84
3 7/16	14	9 1/4	4 3/4	2 3/8	6	1/4	1 3/4	3 1/2	11/16	1 3/16	7/8	201.33
3 11/16	15	9 7/8	5	2 1/2	6 1/4	1/4	1 7/8	3 3/4	11/16	1 3/16	7/8	254.91
3 15/16	16	10 1/2	5 1/2	2 5/8	7	1/4	2	4	13/16	1 5/16	1	279.61
4 7/16	18	11 3/4	6 1/4	3	7 3/4	1/4	2 1/2	4 1/2	13/16	1 5/16	1	420.08
4 15/16	20	13	6 3/4	3 3/8	8 1/2	1/4	2 1/2	5	13/16	1 9/16	1 1/4	496.78

Machinery, N.Y.

Clamp Coupling Dimensions.

table gave excellent satisfaction. The smallest size of shafting used anywhere about the mill is 2 15-16 inches diameter and not a great deal of this size is used, but I have calculated the other sizes so as to have the table complete.

We always kept a number of extra bearings on hand and the millwright who looked after the line shafting used to mark the bearings that showed signs of wear. When for any reason it became necessary to shut down the engine for half an hour or so he would pull out the old bearings and slip in the new ones. The old ones were then babbitted at his leisure and were then ready for a new place.

Rutland, Mass. H. A. HOUGHTON.

TO TRUE UNIVERSAL CHUCK JAWS.

Editor MACHINERY:

The following is a description of a method which I have used and found very effective for truing the jaws of lathe chucks which have been strained or worn out of true to such an extent that they would not hold the work firmly. In most chucks there is quite a thickness of metal in the faceplate between the back of the jaws and the recess which is threaded to screw onto the spindle. If this has been drilled through to allow a rod of stock to be put through the hollow spindle of

the lathe, open the jaws far enough to clear, and true this hole up by taking a light smooth cut with a boring tool. Next take a piece of stock about 6 inches long, of sufficient diameter to leave a small shoulder and turn the end to a size that will be a nice running fit in the hole already trued in the chuck faceplate. Then turn the large diameter true for a distance slightly more than the length of the jaws, letting it taper about three or four thousandths inch, the large diameter being at the shoulder already turned. After oiling well, place the end turned down in the hole in the chuck and hold the other end in the tailstock chuck, if there is one belonging to the lathe; if not bring the tail center up, after first placing a dog on the lap, and adjust it so as there will be just sufficient end play to allow the spindle to revolve freely. You are now ready to begin lapping the chuck jaws true.

Place some emery and oil on the lap and close the jaws of the chuck until the longest one touches the lap; start the lathe on the high speed, holding the lap from revolving by means of the dog. Adjust the jaws from time to time until all of them are found to have a bearing on the lap their whole length. The advantage of this method is that if the jaws of the chuck are loose, when you screw them down on the lap they take the same position they would when tightened on a piece of work in the chuck, and when the job is finished if carefully done they will be found to have a parallel grip on a straight piece of work.

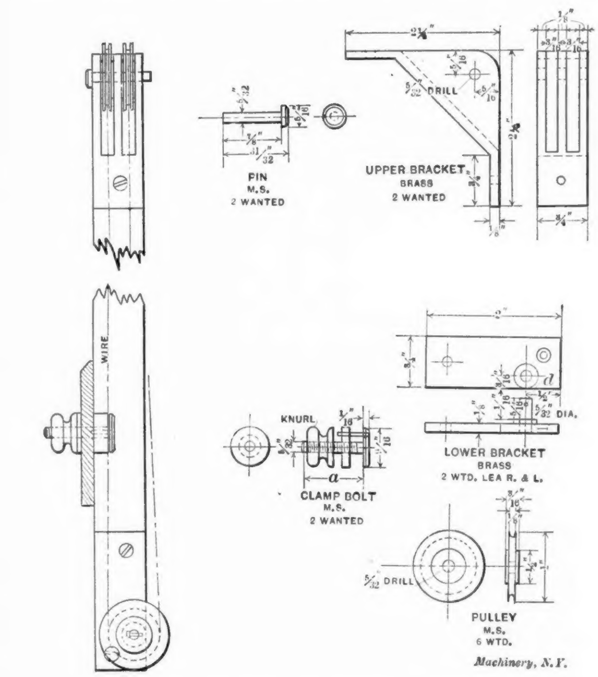
This method can also be used in truing up large chucks by placing the lap on the centers, being careful to keep the live center well supplied with oil. If, after truing the inside you wish to true the outside of the jaws you simply tighten the chuck on a perfectly round piece of stock and grind the outside with a grinding attachment. J. E. MANIERRE.

New York.

PARALLEL MOTION FOR DRAWING BOARD.

Editor MACHINERY:

Seeing the description of parallel motion for drafting boards by V. A. H. in the August issue, I decided to send details of fixtures that I have on my drafting board. I have used this motion a good deal and consider it far ahead of any T-square



Parallel Motion for Drawing Boards.

as it will stay where it is put, is of easy action and it needs no care to draw a line the full length of the board, as one end of straightedge is as firm as the other.

The wire (for I use music wire No. 2 instead of cord) is crossed on the edge of board away from the draftsman and passed over pulleys on each end. The ends of the wire are connected by a small spiral spring of sufficient stiffness to keep the wire under tension. An end of the board is shown at *A*, with straightedge fastened to wire. The straightedge can be slotted where clamping bolt passes through, which will allow it to be set at an angle if wanted. The upper corners of the board are cut away at an angle of 45 degrees to allow the upper bracket to set up to the board; the brackets are fastened to the board by common wood screws. The pins for the upper bracket are a snug fit in same and pulleys must have hole large enough to allow them to turn freely. A pin is forced into the lower bracket and a small hole drilled at *A*, for a pin, not shown in detail, which is used to keep the pulley in place.

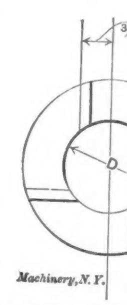
The board proper in my drafting table being but ¾ inch thick I have the brackets made ¾ inch wide, but they can be made any width, the idea being to have the upper wire on ends as nearly parallel with top of board as possible. I put a small pin through the head of the clamping bolt and its washer, to prevent it turning when tightening same. The dimensions of washer and dimension *a* are not given, as these depend upon the distance from upper wire to under side of straightedge and the thickness of the straightedge.

Athol, Mass. H. M. B.

REGARDING THE TEETH OF HOLLOW MILLS.

Editor MACHINERY:

I have read with interest Mr. Markham's articles in MACHINERY, and consider that they, in a general way, fittingly typify the art of toolmaking as it applies to the modern toolmaker and toolroom practice. While the articles in question are no doubt written for the beginners in their line of work, they can, I believe, be read with profit by the experienced workman as well. When it comes to the cutting of teeth in hollow mills, however, I take exception; from a careful reading of the article relating to this class of tools and reference to the illustrations, I come to the conclusion that he sets the face of the teeth in mills on a line with the center; or radially, which is different from what I have been in the habit of doing when making these tools for the machining of steel or cast iron.



Hollow Mill with Tangent Cutting Faces.

While working in from fifteen to twenty shops I have had frequent occasion to observe the action of these tools, principally, for the rapid reducing of bar stock in the turning of screw machine work, and, from these observations I have been led to believe that the most noteworthy point to take into consideration is the proper cutting of the teeth sufficiently in advance of the center to insure a keen cutting edge and give somewhat of a side rake which is not possible to develop when the teeth are in line with the center. For brass, I always cut the teeth straight and on the center; for cast iron and steel, more especially the latter, we cut them spiral or straight, and for general practice ahead of the center. The rule I adopt when cutting the teeth is to set the side of the milling cutter from 5-16 to ⅜ of the diameter of the hole in the hollow mill in advance of the center; the sketch gives an idea how it looks when finished. Clearance is given the mills in same manner as Mr. Markham describes, either by taper reaming from the back or by grinding internally; also we bevel the teeth when possible at the cutting end so that the tool may center itself and last longer. C. H. ROWE.

Worcester, Mass.

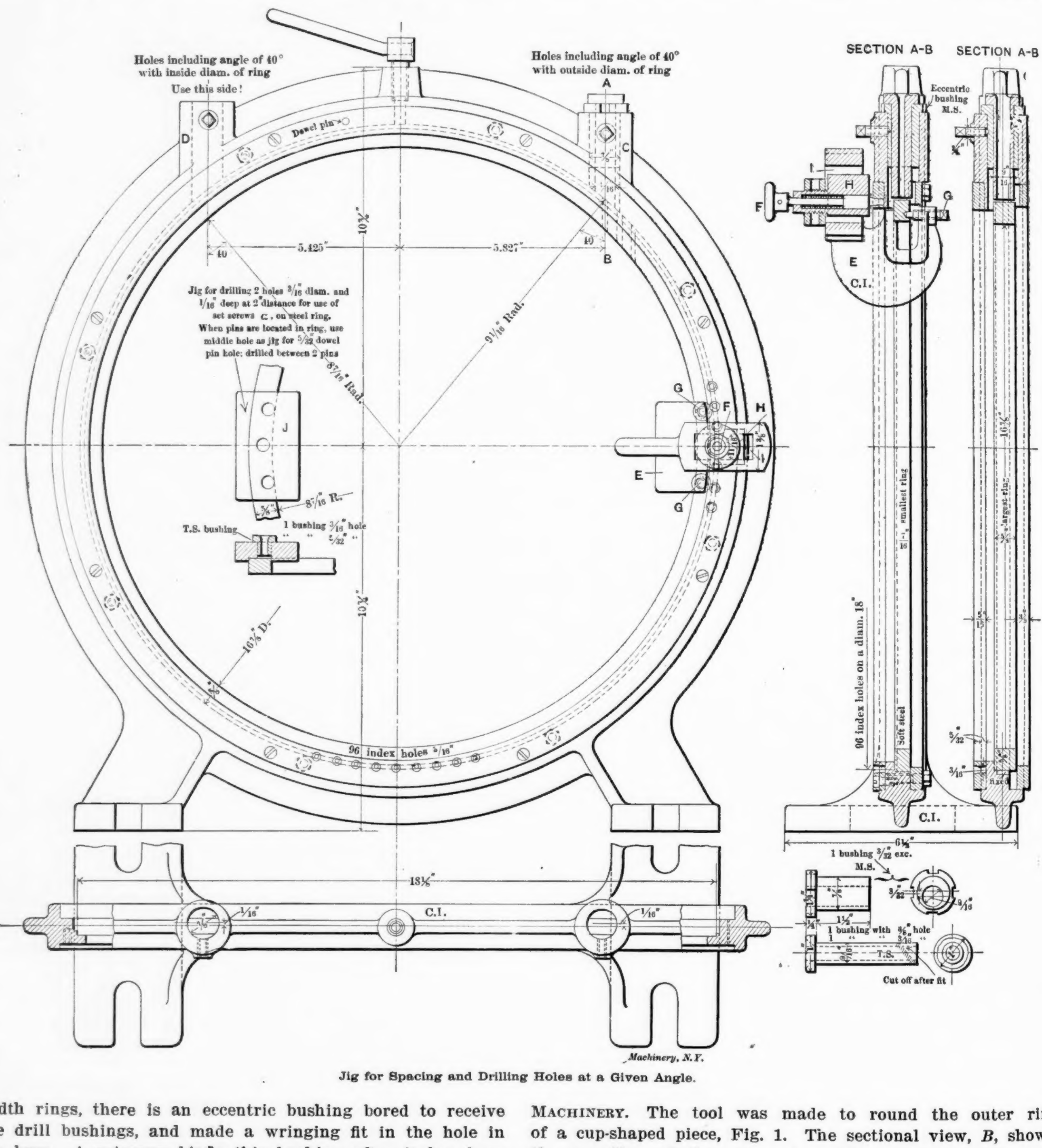
JIG FOR SPACING AND DRILLING HOLES AT A GIVEN ANGLE.

Editor MACHINERY:

One of the most interesting jobs I have had to deal with recently, was drilling properly-spaced holes in soft steel rings, at a given angle to the diameter, and a brief description of the operation, together with a drawing of the jig which was used, will I think, be of interest to your readers.

The rings to be drilled, in this instance, were 18½ inches outside diameter, 16⅞ inches inside diameter, by 7-16 to ⅝ inch wide. The rings 7-16 inch wide, having 96 holes 3-16 inch in diameter, and those ⅝ inch wide, 48 holes ⅜ inch in

diameter, drilled, in both cases, at an angle of 40 degrees to the outside diameter of the rings. The jig body consists of a single casting, bored to receive the ring to be drilled, allowing it to rotate freely, and counterbored at either side for the indexing ring and the retaining, or cover ring, which is removed when the work is finished and a fresh ring is to be inserted. Referring to the drawing, it will be seen that the two bosses, *C* and *D*, which take the drill bushings, are not equidistant from the center line. This difference is necessary to compensate for the thickness of the ring (5/8 inch) and gives at *C*, the same angle to the outside diameter, as that which is obtained at *D*, to the inside diameter of the work, viz.: 40 degrees. To bring the drill central for different



Jig for Spacing and Drilling Holes at a Given Angle.

width rings, there is an eccentric bushing bored to receive the drill bushings, and made a wringing fit in the hole in the boss. A setscrew binds this bushing after it has been swung to the desired position by means of a spanner-wrench. This method of centering the drill changes the angle somewhat, but as all of the holes in one piece of work have the same angle, the result is satisfactory.

The indexing, or spacing of the holes is, really, the novel feature of this jig. This is accomplished by means of the separate fixture *E*, which is fastened on to the work much after the manner of a C-clamp. The two setscrews *G*, engage the two holes spotted on the face of the ring to receive them, and the taper end of the spring-pawl, *F*, engages the taper holes in the index ring. The block *H*, carrying the pawl may be adjusted in the slot *I*, to suit an index circle of different pitch diameter. The small jig *J* is for locating the holes for the setscrews in the indexing fixture, and the central hole in this jig is for drilling the dowel-pin hole in the work after it is finished and ready for assembling. JULIUS LENHART.

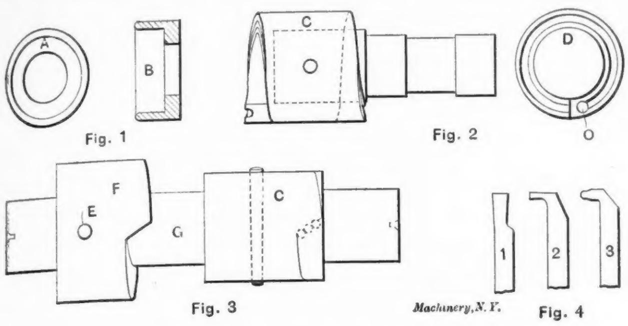
Philadelphia, Pa.

MAKING FORMED CUTTERS ON THE LATHE.

Editor MACHINERY:

I send you some sketches of a rounding tool, which, although it is not new, may interest some of the readers of MACHINERY. The tool was made to round the outer rim of a cup-shaped piece, Fig. 1. The sectional view, *B*, shows the rounding of the outer rim. The material being cast iron and fairly thin, they come hard as a rule, and a mushet tool had previously been used for the rounding. The grinding and keeping in shape of the mushet tool was generally unsatisfactory, and it was decided to make the tool shown in Fig. 2, in two views, *C* and *D*. The tool consists of a hollow shell fitted to a shank for a turret holder. The shell, it will be seen, is a double-ender, so when one end has been used up it can be reversed and the other end used, thereby making two tools in one. The shaping groove is slightly

flared out so as not to leave a square shoulder as the cup is finished all over. A tool of the above description is somewhat out of the ordinary line, requiring some special fixtures for its shaping, but it is, nevertheless, not hard to make, and for the benefit of some of the readers I will give a brief description of how the one in question was made.



Making Formed Cutters on the Lathe.

A cast iron piece somewhat larger in diameter than the forming tool was bored out the same size as the other and fastened to a soft steel arbor, made for that purpose with a setscrew, *E*, Fig. 3. This was placed in a universal milling machine and a cam cut out on the end of the cast iron piece with a lead of ⅝ inch to one turn; the short part of the cam was dressed off with a file to the proper shape. The blank cutter was then placed on the same arbor and secured with a taper pin. With the work mounted as shown in Fig. 3, the arbor was placed on the centers of the lathe and driven with a dog in the usual manner. A piece of 1-inch square iron, *H*, Fig. 5, was drilled for a bolt in the middle and a ⅝-inch pin at the end and at right angles to the bolt hole. This piece was bolted to the outer edges of the toolpost saddle. Another piece, *L*, of the same section but somewhat longer was drilled a loose fit for the pin, *M*, and a smaller pin, *N*, was put through the piece, *L*, and the ⅝-inch pin, *M*, to form a hinge on which the piece *L* might swing. The other end of the piece, *L*, was turned down to receive a roller, *K*. The roller was made crowning with a radius equal to the distance from the center of the roller to the pin *N*. A feed screw, *J*, was tapped through the end of the piece *L* and the point was sunk into the piece *H* for support. A rope, *P*, was fastened to the carriage and run under the headstock and over an idler sheave fastened to the gear bracket. A weight, *W*, was fastened to the rope to keep the roller, *K*, against the cam; the apron of the carriage, of course, was disconnected.

The first operation was to trace the outline of the cam on the cutter blank with the tool No. 1, Fig. 4. The blank was then taken off and where the short rise of the cam takes place a few holes were drilled, indicated by the dotted circles in Fig. 3, and the rest of the stock was taken out with a file. This was necessary in order to relieve the tool of the scraping action when being forced out by the cam. The outline of the cutter was then cut by feeding in the cross-slide carrying the tool No. 1, several cuts being necessary. The roughing tool No. 2 was next used, the relative position of this tool and the finishing tool No. 3 with the roller *K* in starting the cut, being shown in Fig. 5. These tools are sunk into the blank by placing a wrench on the feed screw *J* and giving it a slight turn to the left for every turn of the cam. In order to relieve the tools Nos. 2 and 3 of the top scraping out, at the rise of the cam, a hole is drilled at the end of the groove, as shown at *O*, Fig. 2.

One end of the forming tool being completed, the taper pin was removed and the blank reversed. The short incline of the cutter is left until after the hardening, when it is ground for cutting. CHARLES THIEL.

Lawrence, Mass.

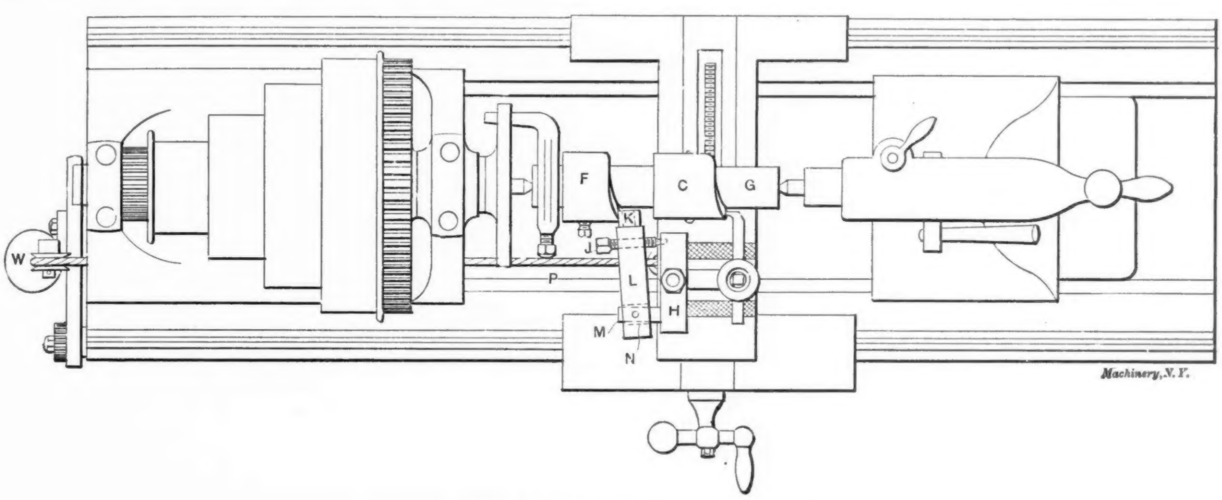


Fig. 5. Lathe "Set-up" for Making Formed Cutters.

LATHE RIG FOR TURNING MACHINE HANDLES

Editor MACHINERY:

I had the pleasure of rigging up an old engine lathe some time ago for the purpose of turning machine handles used in the construction of various machines, and it seemed to me it was a very neat and cheap way of obtaining the required shape, as well as finish necessary to make a good machine handle, although this method may have been employed for the same purpose before.

Fig. 2 shows sample of machine handle to be finished—swung between centers and driven by dog, *K*; the taper attachment is used with the taper bar, *T*, Fig. 3, clamped so as to be in a parallel position with spindle of machine and planed out so as to allow plate *B*, Fig. 1, to be screwed and doweled upon its surface. The former plate is laid out from the outline

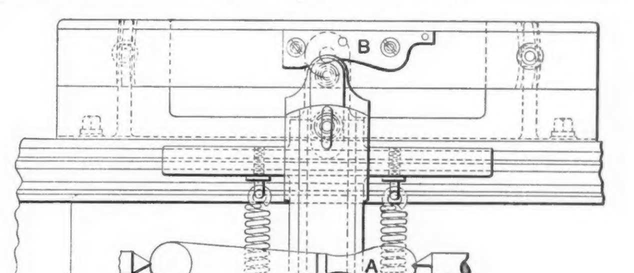
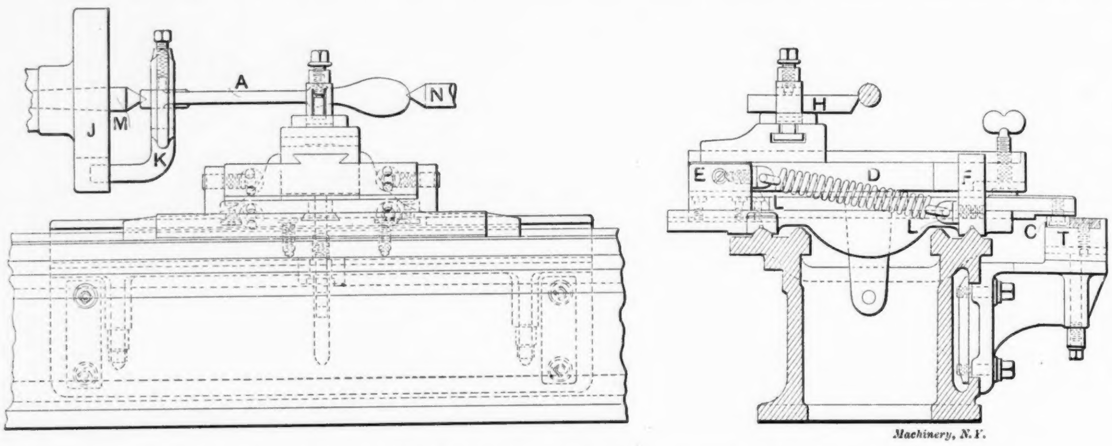


Fig. 1. Lathe Rig for Turning Machine Handles.

of the handle *A*, and the curve is generated by using, in this case, a one-inch roll. Fig. 3 shows tapped holes with eyebolts *L* inserted in the toolpost slide *E*, and also in carriage *F*.

With these two points connected with coil springs, *D*, which

hold the roll *C* in contact with the face of the former plate *B*, Fig. 1, tool *H*, with the proper feed applied through lead-screw, follows the outline of the former, thus giving the required shape of handle. With a former plate for each size handle, the outfit is complete.



Figs. 2 and 3. Side and End Elevation of Lathe Rig for Turning Machine Handles.

Of course this method is not limited to this class of work alone. It may be used for many kinds of forming work, where a large enough quantity is required to make it pay to make former plates. DRAFTSMAN.

HOW THE PILLOW-BLOCK SEAT OF A LARGE ENGINE WAS PLANED OUT WITH A SMALL PLANER.

Editor MACHINERY:

E. J. Buchet.

The accompanying photographs, Figs. 1 and 2, show how we had to do a heavy job of planing in a shop equipped with small tools. The job in question is an engine bed weighing 12 tons, which had to have a seat planed out at right angles for the pillow-block. As no planer in the shop was large enough to carry the job, the alternative was adopted of making one of the planers act as a shaper, but the first thing to do was to get the casting into position. No cranes being available, the casting was mounted on rollers like those used for house moving. The chain was made fast to one end of the bed and a long rope fastened to it, was wound round the table of a 10-foot boring mill. Then the boring mill table was started up,

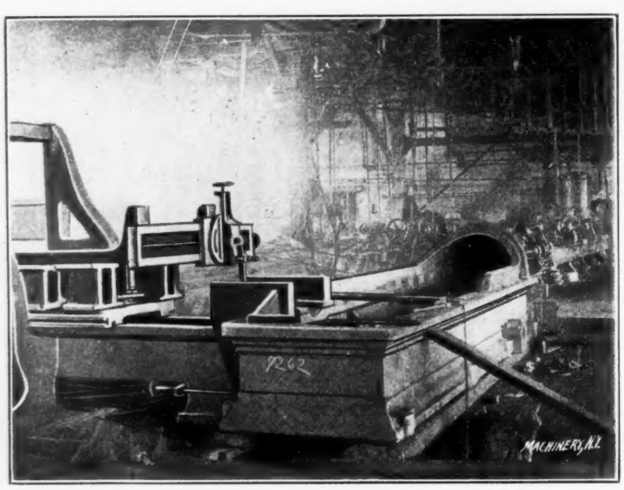


Fig. 1. Planing Pillow Block Seat with Small Planer.

and the engine bed pulled into position behind the biggest planer in the shop. Here it was lined and leveled crossways to the travel of the planer platen, and a short distance below it. The cross-rail was taken off another planer and bolted to the back of the planer platen by means of angle irons. The cut was taken on the backward stroke of the planer platen. A very good job was done in this manner and in a reasonable length of time. E. J. BUCHET.

Dubuque, Iowa.

ERNEST J. BUCHET was born at Dubuque, Iowa, June 2, 1870. His early education was limited to common schools. He served a four years' apprenticeship with the Novelty Iron Works, and besides this concern he has worked for the Iowa Iron Works, the Chicago, Milwaukee, and St. Paul Railroad, etc.

"FRICTION OF SLIDING KEYWAYS."

Editor MACHINERY:

Your very instructive article, "Friction of Sliding Keyways," in MACHINERY for November reminds me of serious trouble I had many years ago. I encountered the defects of splined driving shafts in their most serious form, viz.: in heavy tapping machines for pipe threads. In those days tapping six-inch pipe threads was something to boast about; and it really was—when you tried to get a splined shaft to follow such a tap. Generally, when the tap took hold, the wheel on

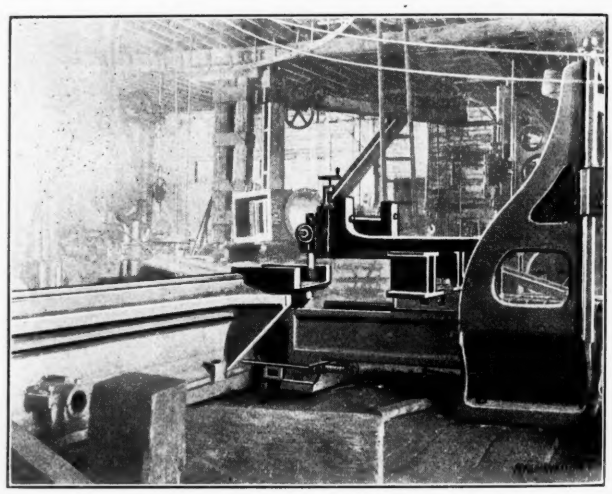


Fig. 2. Planing Pillow Block Seat with Small Planer.

the main spindle did just the same thing; then as the tap led into the work it was either torn out of the chuck or the whole table of the machine was lifted. Twenty-one years ago I had reached the point of building machines for my own use and met the difficulty as follows:

In Fig. 1 (next page) a portion of a heavy tapping machine is shown, enough to show the spindle action. In the great wheel *A*, a key like *N*, having radial sides, is driven in fast, but is a sliding fit for the spindle *C*, which has the keyway cut full length. Wheel *A* has a clamp hub, and this along with the clamp collar *D*, permits the spindle *C* to be set to any height suitable to the work on hand. When set, wheel *A* and clamp collar *D* are practically solid parts of spindle *C*, and grasp the square rack *B*, in which the spindle rotates. This rack *B* is actuated by a pinion in rear of bearing *J*, giving feed as per *L*.

As the spindle *C* is fed down to its work the wheel *A* goes along, traveling on the long pinion *E*, which is the driver. Pinion *E* receives power through bevel gear *F*, from back

gearing. So A, B, C, D and G move as one piece, balanced by wire ropes, M M, passing over pulleys. Solid black represents section through bearings in machine frame; section O being in another plane to take the pinion E behind the great wheel. This also allows cross beam G, which is fastened to the top end of the rack B, to pass over wheel F, till it strikes top of bearing J, as indicated by feed distance L. This combination follows an eight-inch tap without any noticeable drag. Apparently it is because the teeth of E and A are in constant motion on each other and, therefore, the downward motion of A on E is only compounding the movement of translation. Fundamentally, however, it is caused by the fact that the pressure on the teeth of A and that on the key in its hub, vary inversely as their distances from the center. That is, this method of driving reduces the drag of the spindle as much as C is smaller in radius than A. In these machines the great wheels are about eight times the radius of their spindles, but the advantage is greater than this for, since the key is fast in the wheel A, the spindle C would be driven by *less* than its radius, so that the ratio between dragging the spindle C over the key, or allowing A to travel on the long pinion E would be at least ten to one in favor of the system as described above.

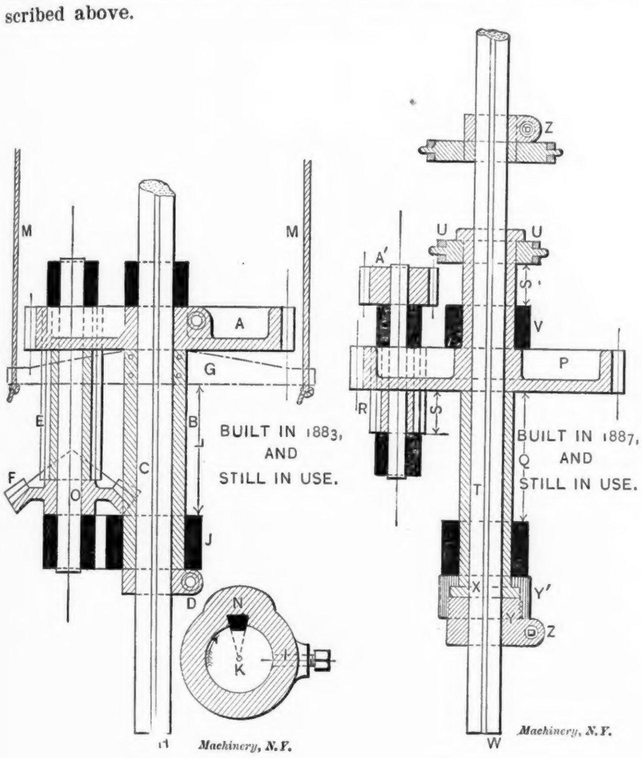


Fig. 1. Fig. 2.

All chucks and taps are fastened to the spindle at H, by sockets, as shown at N I, the flat pointed setscrew at I serving merely to keep the piece from dropping off, since all the driving is done by the radial side key N. The absence of any socket, screw, or hole in the end of the spindle at H is just the very thing which makes it universal. This system by which the great wheel moves *along* the driving pinion E, combined with a spindle having a plain end H, I have been unable to improve to this day. All taps above three inches have this hub and dovetailed key N as part of the tap, so that the spindle of the machine becomes the stem of the tap. Those interested in this "reverse-stem" method of holding taps are referred to photograph of our taps in MACHINERY of January, 1900.

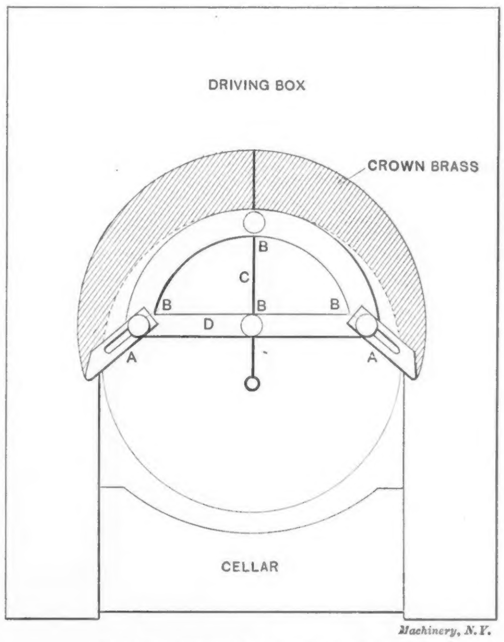
Most of this description also applies to a later machine of 1887, shown in Fig. 2. In this case the great wheel P has a long hub, as shown, and is a sliding fit on spindle T, and is a little overbalanced by a forked lever, the ends of which are shown at U U. Hence it normally remains up against bearing V, as shown; but when the tap takes hold it "bites" the spindle T, and travels with it, through the short spaces S, S which are more than long enough for a pipe thread tap. The instant the tap lets go, the great wheel P, automatically moves up to the position shown in sketch. So unobtrusive and quiet is this action that the average operative in using the machine does not even know of its existence. In moving the spindle over the range of the feed as per distance Q, no downward motion of P takes place, *unless you put work on at* W, when instantly P becomes practically a part of spindle T, and moves along with it. Rack Q in this machine is circular and has a flange on the lower end at X. The pieces Y, Y' may be considered as a solid piece. Spindle T is very long and is balanced by a forked lever as shown, and by shifting clamps, Z, Z, it may be let down to do work lying on the floor. Power comes through the spur gear A', from vertical back gearing. This machine, in action, is just the same as the machine shown in Fig. 1, but the gearing is more compact. The older machine has the advantage in that its great wheel will follow the whole range of the feed, and will therefore take a greater range of work outside of tapping pipe threads.

JAMES ARTHUR,
New York. President The Arthur Co.

TOOL FOR LAYING OUT CROWN BRASSES.

Editor MACHINERY:

Having been helped at different times by short articles and descriptions of tools appearing in your journal, I submit to you a brief description of a tool I both saw and used in one of the shops of the N. Y. Central. To a railroad machinist the drawing will almost explain itself, but to those not of that "fraternity" I give a description which I hope may suggest some other use to which this tool may be put.



Tool for Laying Out Crown Brasses.

The tool consists of eight pieces, as follows: Two blades, A A, four thumbscrews, B B B B, a scriber C and the body D. The cut shows plainly how it looks when assembled. The work it is designed to do is common in railroad shops, i. e., fitting a crown brass to a driving box. To use the tool proceed as follows: Place the two blades A A so that they fit against the flange as shown in the drawing, see that they set at the same angle, then clamp in position; now move the scriber C until it touches the box as shown. This finishes the measuring of the box proper. To transfer the measurement to the crown brass we proceed to lay a scale along the outside of the brass, place the scriber so that it just touches the scale, then scribe along the outside edge of blades A A, and the brass is ready for the machine. This saves a good deal of time over the old method in vogue in many shops.

R. G. D.

* * *

The so-called indelible or aniline pencil is said to be effective for numbering or marking negatives, being used for this purpose on the undeveloped plates. A Stamford photographer says that he has found Dixon's "Eterno" to be the best for this purpose, as its writing is unaffected by the developing or fixing baths.

SHOP KINKS.

A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP.

Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.

HOW A TRIPLE WORM WAS CUT.

Some time ago I was required to make a worm which was to be used on a wire-measuring machine, and as the method used in cutting the worm was a little out of the common it will perhaps be of interest to the readers of MACHINERY. It was made of bronze with a triple V-thread 3½ threads per inch, or 3-10 lead. While calculating the gears to be used in cutting the worm, I found, as there were 3 1-3 threads in one inch, that this trebled would be 10 threads in one inch, and it occurred to me that all other threads could be cut at once using a 10-thread chasing tool, which I did, making a very neat accurate job and saving a great deal of time. The lathe used was a Reed lathe with 5-thread leadscrew. The nut was released at will and all the cuts taken without stopping the lathe.

R. B. CASEY.

Schenectady, N. Y.

TEST GAGE FOR MAINTAINING STANDARD TAPERS.

In steam injector work the requirements for accurately ground reamers of unusual tapers are severe, and the gage shown in the sketch was designed to maintain the prevailing standard. It consists of a graduated bar 1 inch square, with the slot *F*, Fig. 1, running its entire length. The stationary head, *A*, is secured in position flush with the end of the bar, and the sliding head, *B*, is fitted with a tongue which guides it in the slot. This head may be secured in any desired position by means of the knurled thumb nut. The bushings, *D*

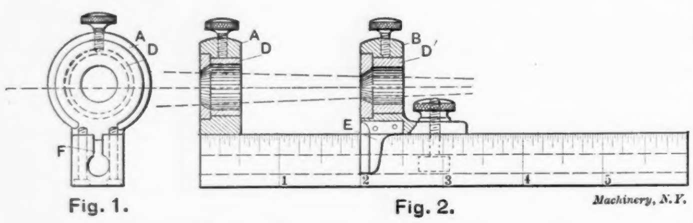


Fig. 1. Fig. 2.

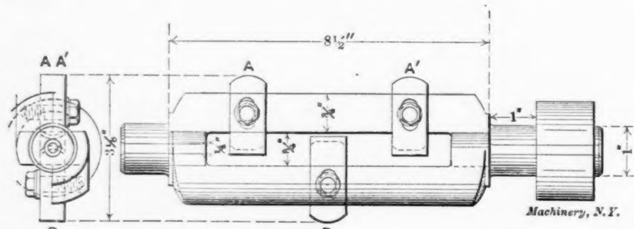
and *D'* are made of tool steel, hardened and ground to a knife edge on the inside, flush with the face. All bushings are made interchangeable as to outside diameter.

The head, *B*, is fitted with an indicating edge, *E*, which is set flush with the knife edge of the bushing. The reading indicates to .01 inch, the distance the bushings are from each other, and the difference in their diameter being known, it is easy to compute the taper. With this gage it is possible to maintain the standard tapers to a fine degree, each reamer being marked with the reading as shown by the scale.

I. B. NIEMAND.

WIRE STRAIGHTENER.

In answer to a request from one who signs himself "Connecticut," asking for information in regard to a wire-straightening machine, I would say that we are using a device which is giving satisfaction. The sketch sent herewith, showing some of the dimensions, which may be varied to suit condi-



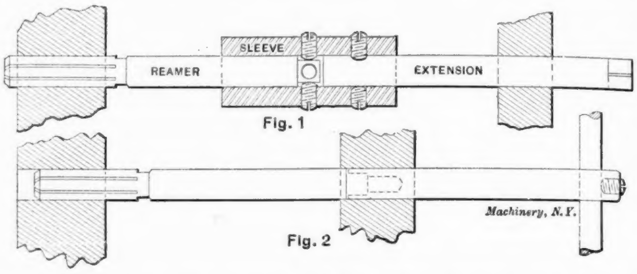
tions, gives a general idea of what it is. We can straighten any size wire in this machine up to ¼ inch in diameter. The lugs *A*, *A'* and *B* are movable and *A*, *A'* should be set at about the center line of the machine. The lug *B*, should be set in past the central line about ¼ inch making a short bend in the wire. Now, by placing the wire to be straightened through the central hole in the journals, grasping it with a pair of pliers and starting the machine, which should run at about 1,000 revolutions per minute, the wire with a slight pull will come perfectly straight from the machine. The lugs *A*, *A'* and *B*, should be concaved or rounded out on the ends where the wire bears, and should be hardened.

E. B. KINGSLEY.

East Syracuse, N. Y.

TWO REAMER EXTENSIONS.

How many times have I wanted a specially long reamer to reach through two holes which were a distance apart! As I was walking through the shop a few days ago I saw a man using a simple extension which filled the long-felt want, and it is so simple and easy to make that I considered it worthy of the attention of your readers. The sketch, Fig. 1, will speak for itself. One screw is sunk slightly into the extension shank to prevent slipping while four screws form a

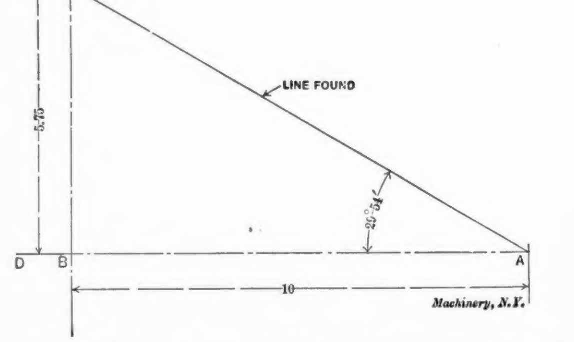


square place in the sleeve to take the square end of the reamer. The sleeve may be made from any kind of a piece of scrap iron, by simply drilling a hole through it the size of the reamer shank. The extension is merely a piece of shafting the same size as the reamer shank. Any ordinary tap or reamer wrench may be used on the square end of the extension. Fig. 2 shows another tap and reamer extension which will suggest to many machinists a good, practical tool for every-day use especially on the general run of jobbing work.

Pearl River, N. Y. H. E. WOOD.

TO LAY OUT ANGLES FROM A TABLE OF TANGENTS.

The diagram illustrates an accurate way to draw without a protractor lines at any angle wanted. Suppose we wish to draw a line at a certain angle with another and take for example 29 deg. 54 min.: First we draw a straight line, *A D*, of indefinite length and measure off 10 inches on the line from *A* to *B*; then find in a table of tangents, etc., the tangent of 29 deg. 54 min., which is .57503 for a radius of 1. For 10



inches it would be $.57503 \times 10 = 5.7503$ or 5¾ inches. Measure 5¾ inches from *B* to *C* at right angles to line, *A B*, draw a line from *A* to *C*, and we have the angle 29 deg. 54 min. This gives results more accurate than many of the protractors.

ARTHUR W. MCALPINE.

Auburn, N. Y.

[Conversely, the angularity of two lines may be found by measuring the tangent and finding in the table what angle it corresponds to.—EDITOR.]

A NEAT SCREW DRIVER.

I send herewith a sketch of as neat a screw driver, for all-around shop use, as I have seen yet. This was first introduced in the shop by one of the tool makers. *A*, Fig. 1, rep-

resents a handle made of cold-rolled stock, is made hollow to lighten it. The knurling gives the hand a good grip. It will not split or become soaked with oil as the ordinary wood handle does. In finishing the hole *B*, if we use ¼-inch, 5-16-inch, or any standard hand reamer, it always gives a taper of about .005 inch at the front end, which makes it convenient

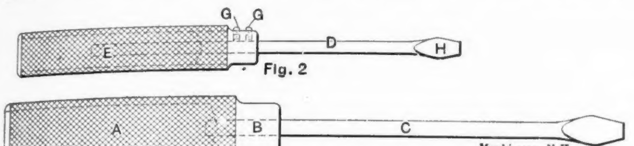


Fig. 1

for a driving fit for *C*, that is, if the reamer is only run in flush with the end of the hole. The smaller screw driver, Fig. 2, is also a convenient tool. The blade, *D*, can be made to fit different-sized screws by making end *H* stronger and larger than *E*. *D* may be reversed by loosening the screws *GG*. PATRICK J. KING.

South Boston, Mass.

MILLING SQUARE JAW CLUTCH TEETH.

By using an odd number of teeth in designing the square jaw clutch it can be milled with only one setting of the cutter and one revolution of the index head.

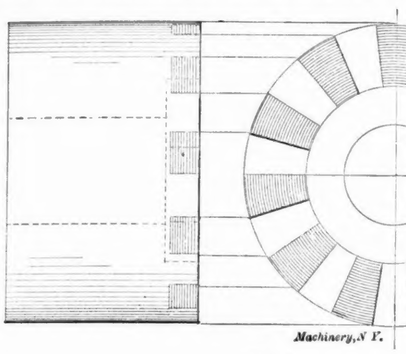


Fig. 1.

Fig. 1 shows one-half of a clutch with an odd number of teeth and Fig. 2 the method of cutting them. Bring the side of the cutter to the center line and cut space, *a* and *a'*, index and cut space, *b*, and *b'*, and so on; when half way round the cutter will only have the corners, *c*, to cut (shown dotted).

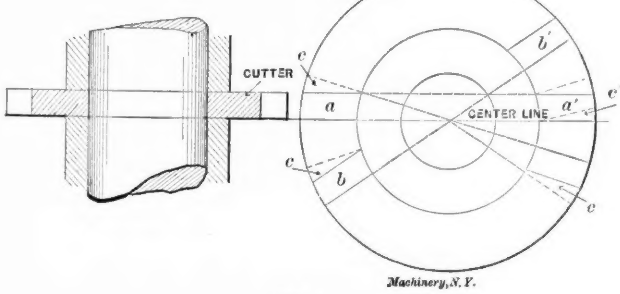


Fig. 2.

The cutter must be small enough to pass through the narrowest part of the space, but need not necessarily be that size. By moving the cutter 0.002 inch across the center line, the clearance between the teeth will be 0.004 inch.

Cleveland, O. DRAFTSMAN.

SIMPLE DRILLING JIGS FOR SHAFTS—WINDING SPRINGS —CUTTING OFF STOCK IN ENGINE LATHES.

The following kinks are some that I have found useful in the shop and I trust that they will likewise be of value to some of the readers of MACHINERY. The first is a jig for drilling shafting which requires two or more holes in a certain fixed relation to one another a considerable distance apart. This scheme requires as many blocks, *A*, Fig. 1, as there are holes to be drilled in the shaft. They are plain rectangular blocks, drilled and tapped on the sides for setscrews and bored for the shafts and drill bushings, as indicated in the cut. These blocks are slipped over the shaft to their proper locations and allowed to adjust themselves by setting on a surface plate or planer table, where they all take their positions automatically. The setscrews are then tightened and the holes drilled. Should it be required to counterbore the holes, the drill bushings may be made removable, and with their outside diameters slightly larger than that of the counterbore.

The second kink is for winding springs in the lathe. A forked holder is made for the toolpost, and is provided with two rollers of the general shapes shown at *A* and *B*. Roller

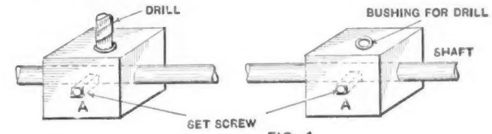


FIG. 1

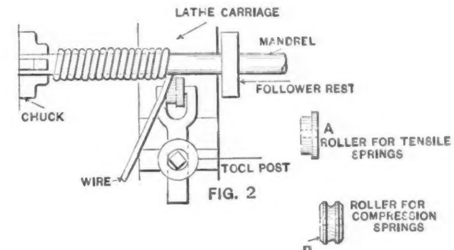


FIG. 2

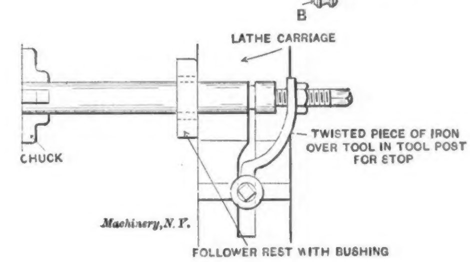


Fig. 3.

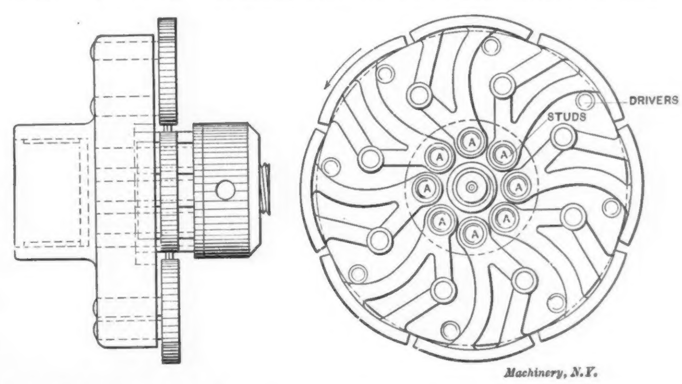
A is used for winding tensile springs, the carriage being moved along by the winding of the spring on the mandrel as indicated in the cut, Fig. 2. For winding compression springs, the carriage is fed by the screw cutting gear set to the proper pitch, and the roller, *B*, is used in the forked holder. A roller with a V-groove does not work as well as the half-round groove shown at *B*.

Fig. 3 shows how stock can be cut off in an engine lathe fully as quickly as in a screw machine. The cut shows the method so clearly that I think it requires no further description. HERMAN JOHNSON.

New York.

FACING SEGMENT GEARS.

We had a large number of drop-forged segment gears to finish. The drilling, reaming and facing of hubs were done first; next they were driven on an arbor, and the sides of rim faced. We used a straddle tool with inserted cutters on this

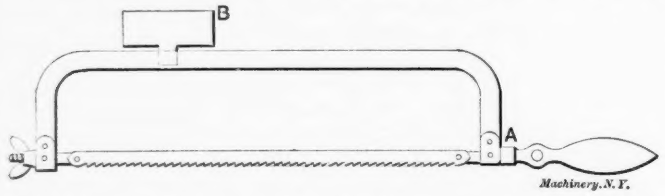


job, facing both sides at once. To watch this tool standing idle for about three-quarters of the revolution was aggravating, and in order to avoid this loss of time I devised a fixture like the accompanying sketch. The segments are slipped on the studs, *A*, and against the driver pins; the large nut holds them firm. By using a gear cutter that cuts the teeth to length at the same time they are shaped, the turning of the outside of the segments was made unnecessary. H. G.

Cleveland, O.

USING A HACKSAW AS A PARTING TOOL IN THE LATHE.

Having a number of pieces to saw in a hurry, I placed one in the power hacksaw and started it going and then fitted up a common hacksaw so that it was used in the lathe with great success on another piece. A ½-inch hole was drilled through the handle at *A* and a small weight was put on at *B*. A ½-inch arbor was clamped in the tool post parallel with the ways, and the hacksaw mounted on it by slipping it through the hole *A*. The work was caught in the chuck, and as it rotated under the saw the cross-slide was moved across slowly as the sawing proceeded. I have since used this scheme more than once with good results, especially on any piece that has a hole through it. The saw does not work so well on solid stock as it is liable to break as it nears the center. I cut small gears or pulleys in halves in this way in a fraction of the time required with a parting tool, and with very little loss of stock. The weight required is small, being not over 8 or 9 ounces.



ROBERT B. OTIS.

Orange, Mass.

* * *

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

The following questions are referred to the readers for answers:

15. S. H.—Can you inform me of some solution for cleaning highly polished iron or steel?

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16. L. M.—What is a good preparation to put upon zinc or tin sheets so as to make a good and permanent black or dead flat surface for templet work?

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17. E. H.—What are the best methods, tools, etc., to use in turning off granite rolls of about 8 inches diameter by 10 inches long, having a 1½ inch hole through them, and properly affixed to a permanent shaft?

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18. T. T. V.—We have experienced much difficulty with the thick, hard scale left on crucible cast steel after the annealing process. The acids we have tried, though they remove the scale nicely from forgings and cast iron, leave thick, hard patches on the crucible steel apparently untouched. These patches are of course very destructive to the cutting tools. Can you perhaps inform us of a process that will entirely remove the scale?

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19. M. M.—I have tested the solution for which a formula was given in this department in the September number, for a non-corrosive soldering fluid, and find that it does excellent work. The expense of the preparation is an objection in my case, however, and I would like to inquire of your readers if there is any other less expensive compound for the purpose. Could the grain alcohol be diluted or some other ingredient be used in its place?

Answer to Question No. 3.

In the September number was an inquiry by H. J. N. regarding the use of aluminum for gas or gasoline engine castings. He wished to know whether an aluminum mixture could be used for the bedplate or other castings. This is replied to by R. M. W., who says: "I have found the best composition of aluminum for bedplates, etc., to be McAdamite, made by the McAdamite Co., New Brighton, S. I. It is much stronger than any other aluminum alloy I have had anything to do with. It has the same ring as steel and when broken the fracture has the same appearance. I hardly think it would be suitable for cylinders as its melting point is about 1,000 degrees, the same as that of pure aluminum. The composition is a secret, but H. J. N. could probably get fuller information by writing direct to the firm."

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20. Subscriber.—Is it considered good practice to run steel gears at 1,200 to 1,300 feet per minute when used in machine tool construction? Should both gears be of the same or different material, and if both are of steel should both be hardened?

A.—We referred this question to the Boston Gear Works who replied: "We should consider the speed mentioned by your subscriber as the extreme limit for durability. We would suggest that gears running at this speed would probably give better results by having them casehardened. We should not consider cast iron suitable for the purpose, as the gears would probably wear rapidly. Neither should we consider that steel gears would wear well if of soft steel not hardened. It would be better still to have the larger gear of hard brass, and the smaller one of a good quality of steel not hardened. If well lubricated, we believe that good results could be obtained at the speed mentioned."

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21. C. G. R.—Can you tell me where I can get information about the transmission of power by frictional gearing, like the Evans friction cone and similar devices? Is there any book published on this subject?

A.—There is no single book treating on this subject, but reference will be found to transmission by frictional gearing in works on machine design, notably Unwin's and Reuleaux's. The best information that we have, however, is to be found in a contribution upon "Paper Friction Wheels," by W. F. M. Goss, in the transactions of the A. S. M. E. for 1897. Prof. Goss conducted a series of experiments by means of two pulleys held in frictional contact, one an iron pulley, and the other of compressed strawboard. In accordance with the usual practice of selecting the yielding material for the driver, the strawboard wheel was made the driver and the iron wheel the follower. The driver was on a shaft with a belt pulley from which it received its power, and the follower was connected with a band brake for measuring the power transmitted. As a result of the experiments he gave a formula for H. P. transmitted, which is reproduced below. Let d = diameter friction wheel in inches; w = width of face in inches; N = revolutions per minute. A coefficient of friction of 0.2 is assumed, and a pressure of 150 pounds per inch width of face at the contact surface. Then,

$$\text{H. P.} = \frac{150 \times 0.2 \times \frac{1}{2} \pi d \times w \times N}{33{,}000} = .000238\, d\, w\, N.$$

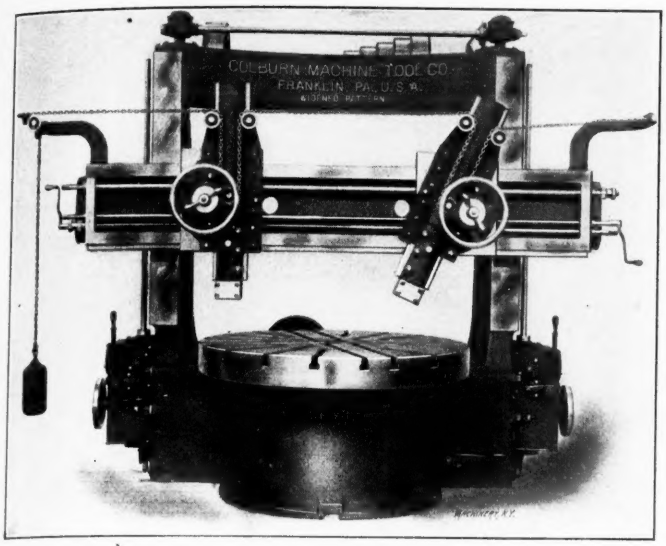
The uncertain quantities in the above formula are the pressure allowed at the points of contact of the two pulleys, and the coefficient of friction. The values used are based on the following considerations: The coefficient of friction was found to be constant, nearly, for all pressures of contact up to a limit which lies between 150 and 200 pounds per inch width of wheel face, beyond which limit its value apparently decreases. It also varies with the diameter of wheel. Paper wheels of 8, 12 and 16 inches diameter gave nearly the same coefficient, but one of 6 inches showed a 10 per cent decrease in the coefficient. The formula as given, therefore, does not apply to pulleys less than 8 inches in diameter. The coefficient is not affected by variations in peripheral speeds between 400 and 2,800 feet per minute. It shows the greatest increase with the per cent increase in the slip between the friction surfaces. A slip of 1 per cent. gave a coefficient of 0.14; a slip of 2 per cent. a coefficient of 0.2; and a slight rise above 2 per cent slip gave a rapid rise of the coefficient to 0.3, after which with an increase of the slip above 3 per cent the coefficient of friction drops rapidly and the wheels are unable to carry the load. From the foregoing, therefore, it is evident that pressures should not go beyond 200 pounds per inch width of face, and that the load should not be great enough to increase the slip beyond 3 per cent at the outside. The coefficient of friction of 0.2 can be used for leather in lieu of any better value as well as for paper. It is generally assumed in the transmission of power by leather belting that the coefficient lies between 0.25 and 0.3, so that 0.2 is evidently a safe value.

NEW TOOLS OF THE MONTH.

A RECORD OF NEW TOOLS AND APPLIANCES FOR MACHINE SHOP USE.

THE COLBURN WIDENED BORING MILL.

The accompanying half-tone shows the 72-inch boring mill brought out by the Colburn Machine Tool Co., Franklin, Pa. They have applied the widening principle to this tool, so that by widening the bed casting and substituting a new



Colburn Widened Boring Mill.

cross rail and top brace the mill has an actual swing of 74 inches. Apart from these changes, and cone pulleys with wider faces for a 4-inch belt, this mill is built entirely like their regular 60-inch pattern. The tool is particularly useful for shops occasionally having large pieces to turn and bore out but not enough work to warrant the purchase of a heavy type 72-inch mill, also for work of large diameter but comparatively light or medium character. It is heavy enough for the use of high-speed steels on all cast-iron work but not for rapid turning on such work as locomotive steel tires.

There are 10 changes of speed for the main spindle, arranged in geometrical progression. The main driving mechanism is contained in a separate headstock placed between the housings at the rear. This headstock can be removed, should it be necessary to take the machine apart. The main drive on the table is by spur gear and pinion.

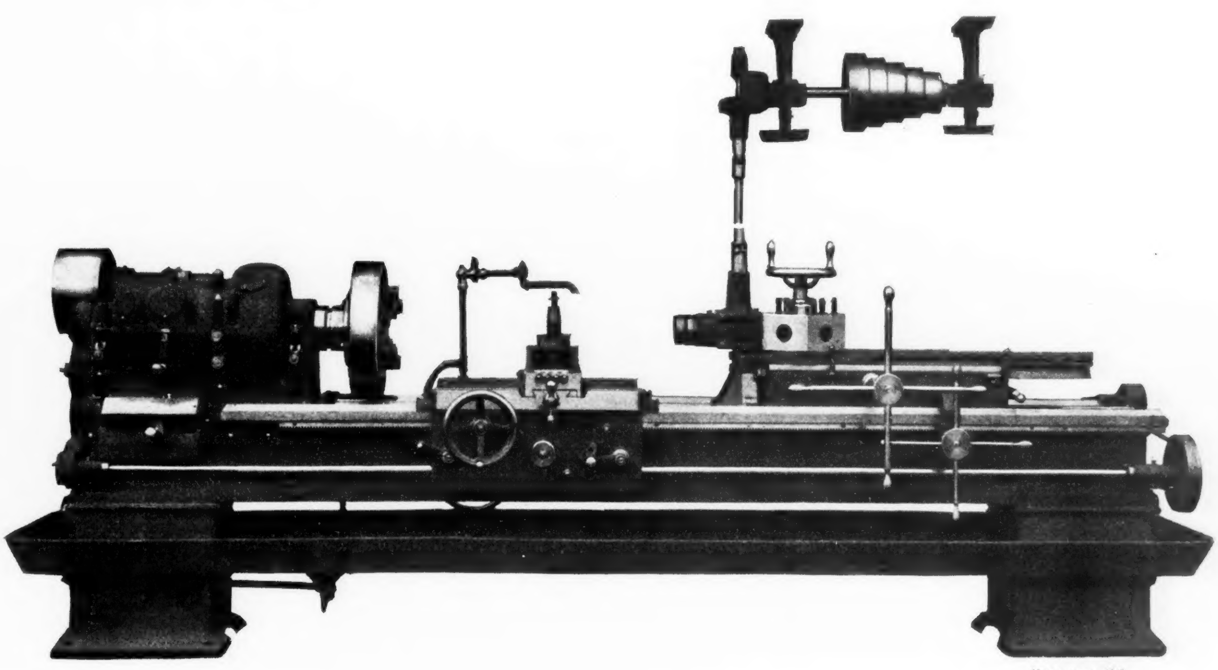
The heads are entirely independent in their movements and can be set to any angle. There are 10 positive feeds for each head, ranging from .025 to .500 inch horizontally and from .020 to .400 inch vertically. The feed boxes on each side are conveniently located for the operator. Turning the handwheel one revolution gives five changes of speed, and a multiplying lever in front changes the gear ratio, so that five more changes can be had by turning the handwheel a second time.

The hand lever near the top of the feed box is for reversing the feed or stopping it. All these feed changes are secured without stopping the machine. A friction brake, operated by a foot treadle within easy reach, eliminates all shock and jar and will stop the table instantly in any desired position.

A thread-cutting attachment, which can be applied at any time to the right or left-hand head, is supplied with this mill and will cut from 4 to 13, including 11½, threads per inch The principal dimensions are: Swing, 74 inches; maximum distance under cross rail, 47 inches; table diameter, 58 inches; travel of rams, 26 inches; length of cross rail, 9 feet 6 inches; floor space required, 12 feet by 7 feet 10 inches; weight, 22,500 pounds.

AMERICAN TWENTY-TWO-INCH LATHE.

The illustration herewith shows a 22-inch "American" lathe with patent all-geared head, turret, oil pump, pan and special boring device. The entire screw-cutting mechanism has been omitted on this machine, inasmuch as the lathe is primarily intended for roughing and boring; and the feeding mechanism, while of the same principle as that on the regular "American" lathes, is of a special nature. There are seven carriage feeds, ranging from .2 to .015.



American Tool Works Company's Twenty-two-inch Lathe.

The geared head is simple, powerful and efficient. Only six gears are required to obtain four speeds through the levers shown on the front. The four speeds obtainable through the head, in connection with a triple friction countershaft, supply twelve distinct speeds to the spindle, ranging from 5 to 322 revolutions per minute.

The carriage is fitted with a plain block rest, which is provided with a calipering attachment, consisting of a set

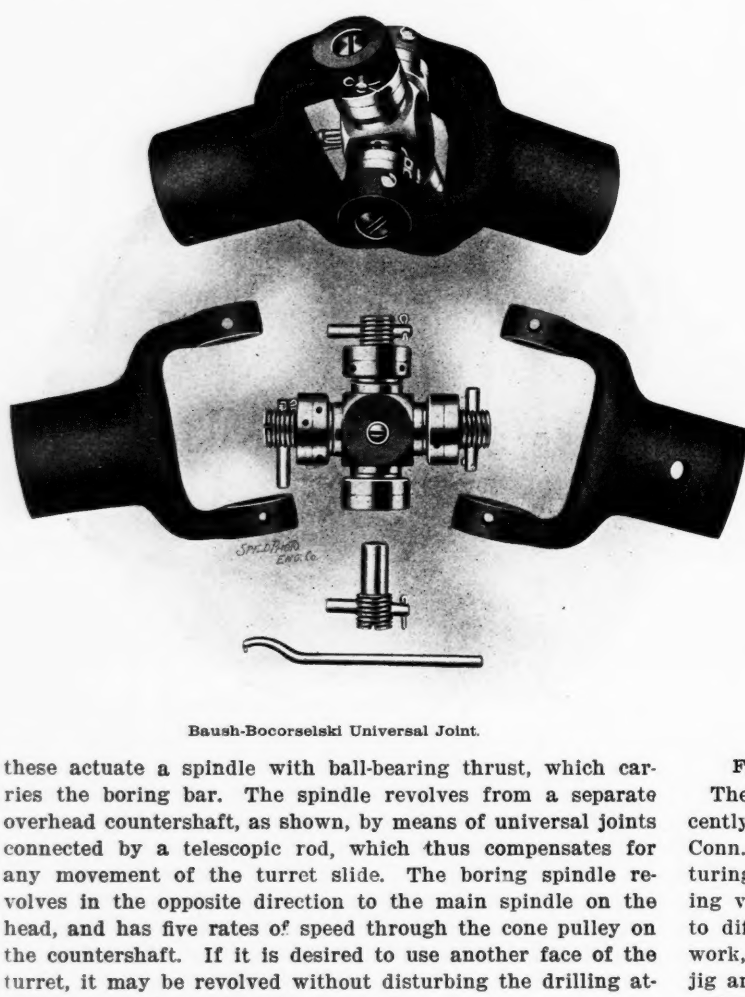
of four adjusting screws, attached to the plain block rest after the manner of eyebolts, each one falling, when desired, over into corresponding slots in the yoke piece over the front carriage dovetail. By adjusting knurled locknuts on any of the four screws and dropping same into the slot, the travel of the cutting tool toward the center, and hence the diameter to be turned, is limited at pleasure. This attachment is very useful in duplicate work, as adjustments can be made for duplicate turning of pieces with four shoulders.

The hexagon automatic turret is of good size, with rapid and easy adjustments. It is provided with power feed, driven by sprocket chain from the feed rod, thus giving fourteen feeds to the turret, ranging from .16 to .007. The worm is dropped out of mesh with the wheel by an improved tripping device. The turret slide has an extra long bearing on the bed; the top slide has a 24-inch movement, controlled by pilot wheel, and is supported on the front end by an improved supporting shoe, which slides on the ways and is firmly bolted to the end of the turret slide directly under the cutting tool. It insures accurate alignment in boring, and has a gibbed bearing both at the top and bottom of the ways, thus preventing all spring in any direction.

The drilling attachment is affixed to one of the faces of the turret, and is very useful in boring operations. It consists of a symmetrical housing carrying miter gears, and these actuate a spindle with ball-bearing thrust, which carries the boring bar. The spindle revolves from a separate overhead countershaft, as shown, by means of universal joints connected by a telescopic rod, which thus compensates for any movement of the turret slide. The boring spindle revolves in the opposite direction to the main spindle on the head, and has five rates of speed through the cone pulley on the countershaft. If it is desired to use another face of the turret, it may be revolved without disturbing the drilling attachment, owing to the telescopic rod.

The boring tool is provided with an oil supply which is drawn up by an auxiliary pump through the turret stem and boring bar. The carriage has an oil supply similar to that of the turning tool.

The lathe is very substantial throughout, to adapt it to the very heavy strains which a lathe of this character must undergo. It is built by the American Tool Works Co., Cincinnati, O.

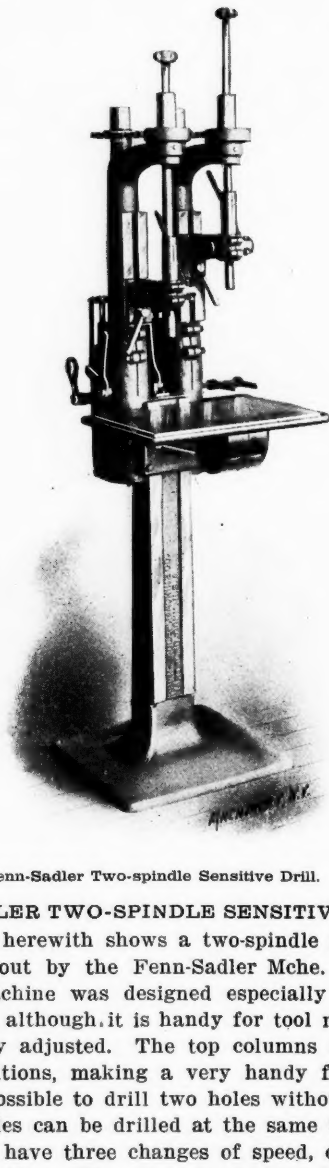


Baush-Bocorselski Universal Joint.

BAUSH-BOCORSELSKI UNIVERSAL JOINT.

The cut herewith represents a new universal joint designed by Frank E. Bocorselski and manufactured by the Baush Machine Tool Co., Springfield, Mass. The joint assembled is shown at the top of the view, in a position of about 15 degrees. It can be run at an angle of 30 degrees. The forks of the joint, shown on the right and left-hand side have a tapped hole to receive a trunnion screw (also shown) with a taper pin passing through it to keep the screw from turning in its fork section. Both the forks and the trunnion screws are of steel.

A novel feature of this joint is the transmission spool or block, shown in the center of the cut. This is of bronze and is bored through from end to end of the projecting arms, to receive the trunnion screw previously mentioned. This also leaves an oil reservoir in the center of the transmission block. The projecting arms have slots in them into which felt is inserted to distribute the oil from the reservoir along the bearing on the trunnion screw and the inner faces of the fork sections. There are two check nuts on each arm, for adjusting the joint to a central position and taking up wear. All the bearing surfaces are steel against bronze. The spanner wrench shown at the bottom of the cut is furnished with each set of joints.



Fenn-Sadler Two-spindle Sensitive Drill.

FENN-SADLER TWO-SPINDLE SENSITIVE DRILL.

The half-tone herewith shows a two-spindle drill press recently brought out by the Fenn-Sadler Mche. Co., Hartford, Conn. This machine was designed especially for manufacturing purposes, although it is handy for tool room work, being very quickly adjusted. The top columns can be swung to different positions, making a very handy feature for jig work, as it is possible to drill two holes without moving the jig and both holes can be drilled at the same time.

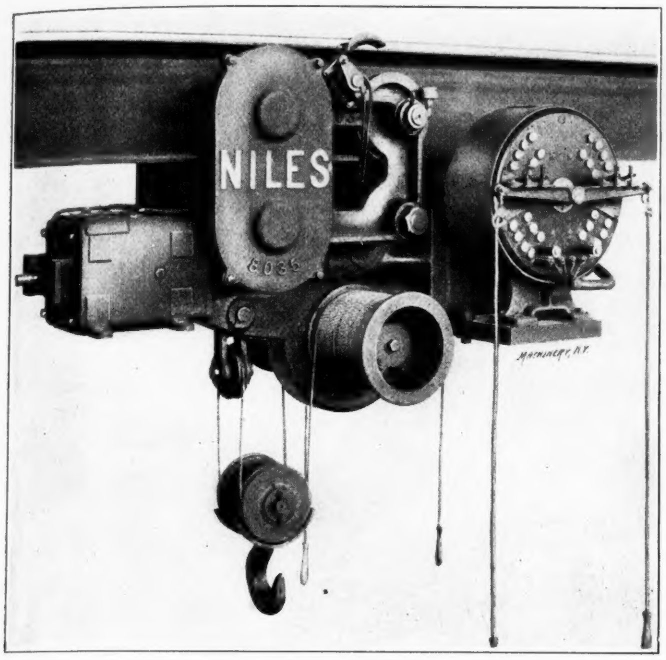
Both spindles have three changes of speed, each one independent of the other. The speed is changed by means of a lever which is operated from the front of the machine. The change of speed is obtained by sliding gears.

The machine is driven by gears. It has but the one belt and is very strong. It is warranted to drill ½-inch holes at the speed that manufacturers desire at the present day.

NILES ELECTRIC TRAVELING HOIST.

The half-tone (next page) shows a new type of hoist built by the Niles-Bement-Pond Co., New York. It is built in capacities of ¾ to 6 tons, and may be used either as a hoist, running on an I-beam track, or for a small capacity crane in which case it is mounted on a traveling bridge. In the latter case it is

arranged to run between two I-beams, or channels, of the bridge, and the controllers for raising or lowering the hook and operating the traversing mechanism may be placed either on the hoist, on the bridge and operated by cords from the floor, or from an operator's cage attached to the bridge. When used on an I-beam the controllers are attached to the hoist and operated by cords from the floor. The hoist will run on straight or curved tracks, and is usually provided with a separate motor for traversing, but if desired hand



Niles Electric Traveling Hoist.

traverse may be furnished, or all the traversing mechanism may be omitted and the trolley moved along the track by pushing on the load. The increased service of the electric traverse, however, more than compensates for the slight additional cost.

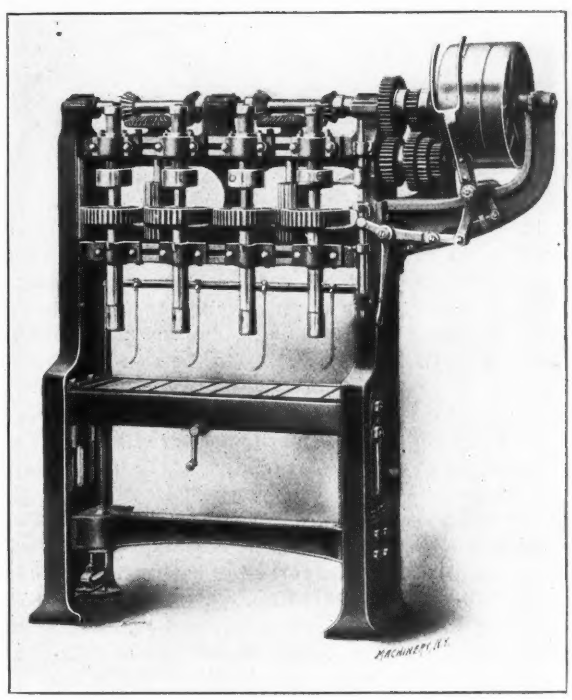
The hoist is self-contained in one heavy cast-iron frame, to which the motors are attached end on, and the power is transmitted directly from the armature shaft to the drum shaft through a train of worm and wheel gears. The traversing mechanism is also driven by worm and wormwheel gears, except that when the trolley is arranged to run on a single I-beam a double set of gears is used to connect the worm gear shaft to the truck wheel shafts. All the mechanism is enclosed in oil- and dust-proof casings. A powerful electric brake is attached to the hoist motor.

NUT TAPPER.

While practically all nuts are tapped by running through them a tap with a long shank on which the nuts are collected, there are a large number of articles which cannot be tapped by this method, since it is necessary in many instances to back out the tap. Any piece which is to be threaded with a taper hole (and this includes nearly all pipe fittings) must have the tap backed out. Also, articles which do not have a hole clear through them must be threaded by first running in the tap and then backing it out. Still other pieces, which are to be tapped only to a certain depth must be threaded by the same process. It is apparent that if a tap is to be reversed it must be provided with a leadscrew of the same pitch as the tap, in order that the tap may not grind around in the hole after it has just cleared the threads. Furthermore, when a positive feed in the shape of a leadscrew is used some kind of a relief is necessary which will yield in case the tap misses the hole and strikes solid metal, as otherwise the machine might be wrecked. Adjustments should be provided for varying the speed, the distance which the taps will move, for cutting threads of different pitches, for running right or left-hand; and means must be provided for quickly and automatically reversing the taps at any desired position.

The National Mchy. Co., Tiffin, O., have brought out a tapper in which the attempt has been made to meet these various requirements. The half-tone shows the general design. Three pulleys—a driving pulley, a reversing pulley and an idler pulley—are carried on the horizontal shaft at the top. Next to the pulleys is a cone of gears by means of which the speed of the tapping spindles may be easily regulated. Below the pulleys and carried on the overhanging arm are a set of levers, by which the machine is automatically reversed at any desired position and then brought to rest with taps in their highest position. Each tap spindle is equipped with a relief device which can be so adjusted that any pressure on the tap—within reasonable limits—will cause it to yield. In addition each spindle carries a sleeve leadscrew, which can be easily removed and replaced by one to suit the pitch of the tap. The tap spindles are made to revolve for either right-hand or left-hand threads, by throwing in either one or the other of the bevel pinions on the top of the machine.

The table is machined on top, and is equipped with T-slots for clamping the jigs which hold the work. It is provided with means for easily adjusting its height. A system of force lubrication is used which not only oils and cools the tap, but also carries away the chips into the movable chip pan. The operation of this tapper is as follows: When the machine is at rest and the taps are in their highest position, the work is secured in the jigs, located on the table; the hand lever is then to the left shifted, throwing the belt on the driving pulley and starting the machine in motion. The taps rotate and descend at the same time, tapping the work, until a definite position is reached at which point they automatically reverse and back out of the holes which they have just threaded; as soon as they reach their highest position, the belt is automatically thrown onto the idler pulley and the machine comes to rest. New work is then secured in the jigs and the operation is repeated.



Four-spindle Nut Tapper.

The machine illustrated occupies a floor space of 6 feet 5 inches by 3 feet 3 inches and has a net weight of 3,000 pounds. The manufacturers are prepared to build jigs for holding any class of work which it is desired to tap on this machine.

ELECTRIC HOIST.

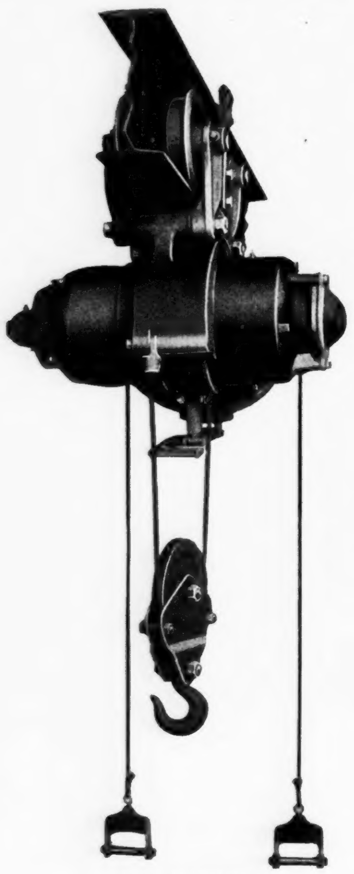
The General Pneumatic Tool Co, Montour Falls, N. Y., have placed on the market an electric hoist known as the Shepard hoist. This apparatus has a number of new features which can be best referred to by taking up the different parts in order.

The motor is fully inclosed but the commutator and brushes are easily accessible and are visible through mica windows.

Two carbon brushes are employed and flexible metallic leads are used to carry the current, to avoid sliding contacts. The armature and field windings may be removed without disturbing other parts of the hoist.

The controller is inclosed in a separate case, independent of the hoist proper, and is arranged for a wide speed control. The segments, while fully protected, are visible at all times. Each contact has an independent magnetic blow-out. The controller is reversible and gives equal speed control in hoisting and lowering. While it is ordinarily mounted on the hoist it may be located elsewhere if desired.

An automatic stop is provided to prevent overwinding. It acts directly on the lower block, and cannot be put out of adjustment by the stretching of the cable. A mechanical brake is provided, to prevent the load from running down when the motor is at rest. It offers no resistance to hoisting but can only be released by reversing the motor and it can be immediately set again should the load descend at a speed slightly greater than that corresponding to the speed of the motor. No current is consumed in loading, aside from the small amount necessary to rotate the motor under no load. The friction surfaces of the brake are submerged in oil. An electrical brake is also applied directly to the armature shaft and is always set at full power unless held off by the current flowing through the armature. The gear consists of a double train of machine-cut and spur gears contained in a sealed case and submerged in oil. This part of the apparatus has been designed like the other parts, so that the gears can be removed without interfering with any other section. Replacing the cover secures the gearing ready for service, and there are no pins, keys or screws to be replaced.

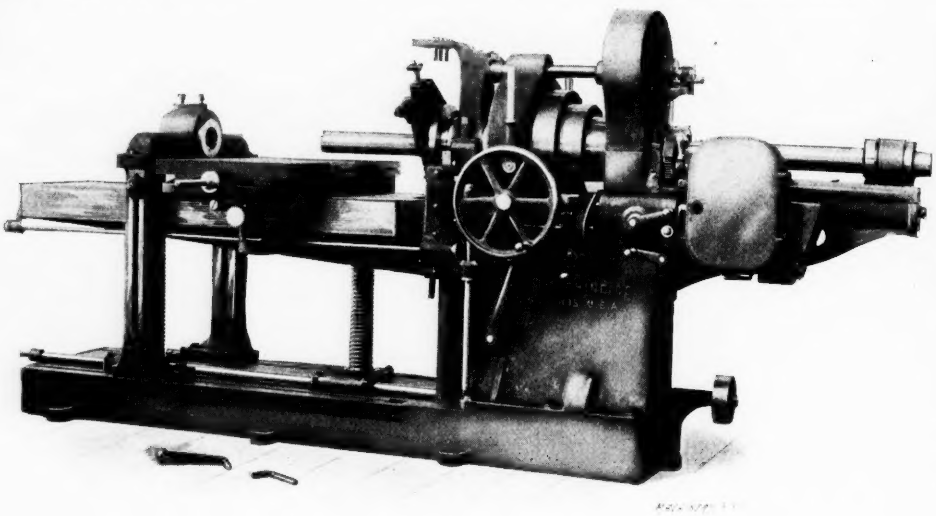


Electric Hoist.

The trolley is made in a variety of forms, one of which is shown in the illustration. It is provided with roller-bearing wheels, having chilled spherical treads, and will be furnished with pendant hand chains or an electric motor, for the traveling movement, if desired. It requires unusually small head room. It is claimed for this hoist that it consumes less power than the worm-driven hoist; that the brakes hold the load positively, without absorbing power while the hoist is operating; and that the accessibility of the various parts, and the wide speed variation, are strong points in its favor.

HORIZONTAL BORING MACHINE.

The horizontal boring machine shown herewith is one of the latest tools produced by the Gisholt Machine Company, Madison, Wis. The headstock is of the friction back-geared type with two sets of back gearing. The boring bar is of hammered crucible steel accurately ground and with taper socket for the insertion of supplementary boring bars. The feed mechanism is of the same type used on the Gisholt lathes, namely, by means of a coarse-pitch screw. The feed is positive and no extra attachment is required for screw cutting. Operating levers are located on both sides of the machine, thus giving absolute control from either side. The table adjustment is a new feature. By the simple movement of one lever convenient to the operator when standing close to his work, the table may be accurately raised or lowered by power and is capable of the finest adjustment. The cross table has a compound movement and is fitted with a power cross feed when desired. Both transverse and longitudinal screws for moving the cross table are fitted with micrometer index dials reading to .0010 inch. The yoke for the table is of the box section form of a very rigid construction and is clamped in the table instead of by use of bolts in T-slots. It carries double bushings for support of the boring bar. This machine is one of several shown by this company at St. Louis.



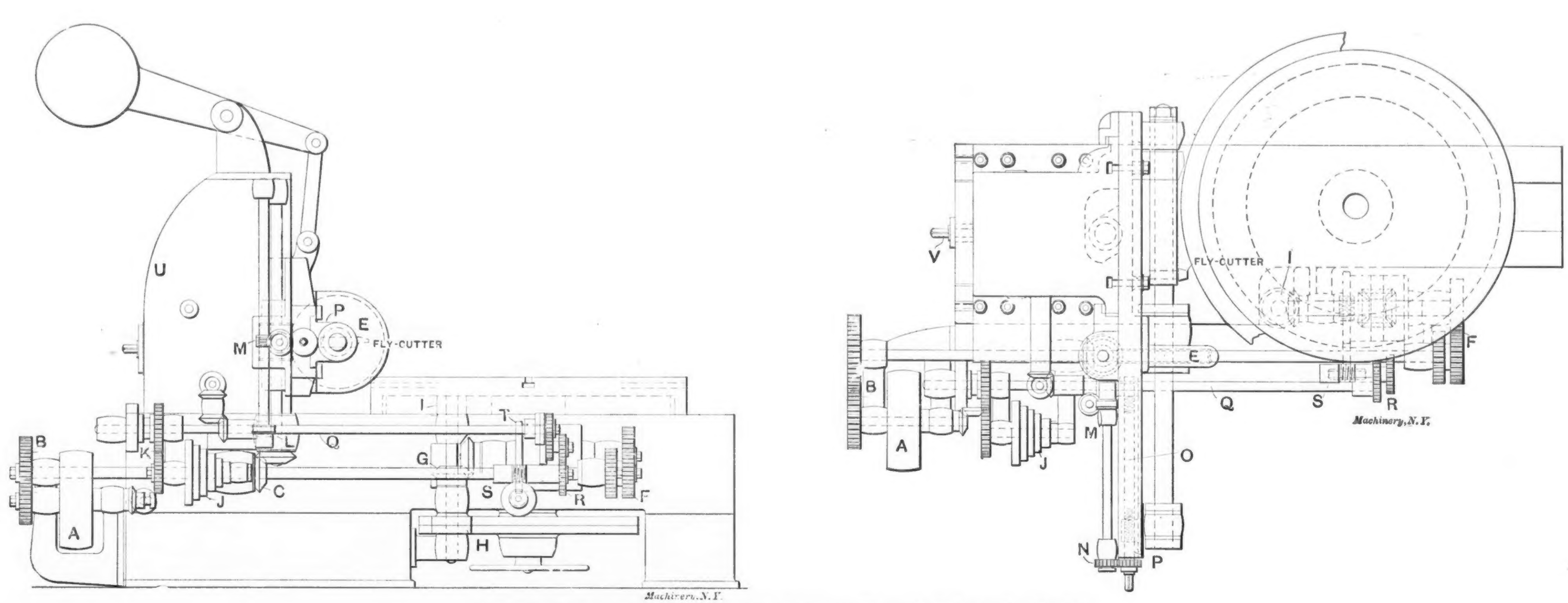
Gisholt Horizontal Boring Machine.

WORMWHEEL GENERATING MACHINE.

The increased demand for a machine to generate accurate wormwheels has led to the design shown herewith. As will be seen, the design is especially rigid; the stiff anvil construction allows of taking very heavy work and heavy cutting without the usual bad strains. The machine is constructed to generate wormwheels either with or without the use of a hob. Although there have been similar machines built for this purpose in Europe, and one in the United States, at the works of Hugo Bilgram, this machine embodies many distinct and original improvements.

The cutter drive and dividing train is driven by the pulley, *A*, thence through the speed-change gears, *B*. The bevel gears, *C*, and worm and wormwheel, *E*, connect with the tool. The horizontal shaft extends to the dividing change-gears, *F*, through the "jack-in-the-box" and gears, *G* and *H*, to the work spindle. The faceplate gears, *I*, are used for driving very heavy work of large diameter, to eliminate all torsion of the work spindle.

The feed-drive and conjugating train are driven from the cone, *J*, thence through the change gears, *K*, worm and wormwheels, *L* and *M*, gears, *N*, to the feedscrew *O*, which gives the slide, *P*, and cutter-spindle the movement or feed tangential to the blank. The shaft, *Q*, connects with the gears, *R*, worm and wormwheels, *S* and *T*, and the "jack-in-the-box," which gives a plus or minus amount to the rotation of the blank. The use of the "jack-in-the-box," or differential gearing, is a very convenient method for giving the blank the same amount of movement along the pitch line, as the tool passes through in feeding endwise, in cutting with the single tool or a taper hob. The two movements, the dividing movement and the conjugating movement, are thus combined, so as to give the blank the effect of both. The conjugating movement alone would give the blank one correct spur notch, gen-



Elevation and Plan of Eberhardt Brothers Company Wormwheel Generating Machine.

erated by the tool. The dividing movement gives the blank the necessary wormwheel rotation, or indexing. Combining these movements through the "jack-in-the-box," the blank is continuously rotated, and at the same time receives the tangential conjugations, so that the result is to produce a perfect generated wormwheel.

In the earlier machines which used the single tool or taper-hob principle, the cutter spindle was supported by a slide underneath it which gave it the required endwise movement or feed. That method of construction required the cutter spindle to be made in a large span between its bearings, and also placed the cutter spindle several inches out from the frame of the machine. In the machine illustrated, the cutter spindle is supported by stationary bearings, and is moved endwise by means of a slide at one end of the spindle. This gives greater rigidity to the cutter spindle, by bringing the bearings closer together, and thus shortening the span of the spindle and placing the spindle close up to the frame.

This machine can accommodate the ordinary cylindrical hob, in which case the tangential feed is stopped by locking the tool slide, *P*. The stanchion, *U*, is then fed forward by means of the screw, *V*, and the hob enters the blank in the usual hobbing manner. The single or fly cutter method is used either to save the expense of a hob, as where only a few wheels of a certain pitch are to be made, or in a case where a particularly accurate gear is required. The fly cutter is the cheapest and yet the most accurate tool for wormwheel generating. It is ground after hardening, thus eliminating the imperfections that develop in hardening hobs. It is simple to make, being merely the shape of a single rack tooth. The standard thread angle 14½ degrees, may be used, but this may be varied to suit special requirements. For instance, where a wheel has a small number of teeth, the angle may be made 20 degrees to avoid under-cutting.

In operation the cutter-spindle is set to the correct center distance by means of a vernier scale on the bed and stanchion. The tool is set out the proper distance from the spindle center (one half the outside diameter of the worm, plus the clearance) and is swiveled to suit the worm thread angle. The tool commences cutting at one side of the blank, and the cutter spindle feeds endwise, tangent to the blank, until the wheel is finished. For commercial purposes, one passing across is sufficient to finish the wheel, but much better results are produced by taking a finishing cut. This method of cutting is not a "nibbling" process; on the contrary, the chips are heavy, and resemble planer chips.

In cutting wormwheels with a fly cutter, it may be valuable to note that considerable time can often be saved by having a "hunting tooth." To illustrate: In cutting a wormwheel of 10 teeth, in which the ratio of wheel to worm is 1 to 1 (a ratio which this machine can easily cut) the wheel would have to be indexed 9 times; whereas, if the wheel could have 11 teeth, to suit a worm of 10 threads, one setting of the fly-cutter would cut the 11 teeth without any further indexing.

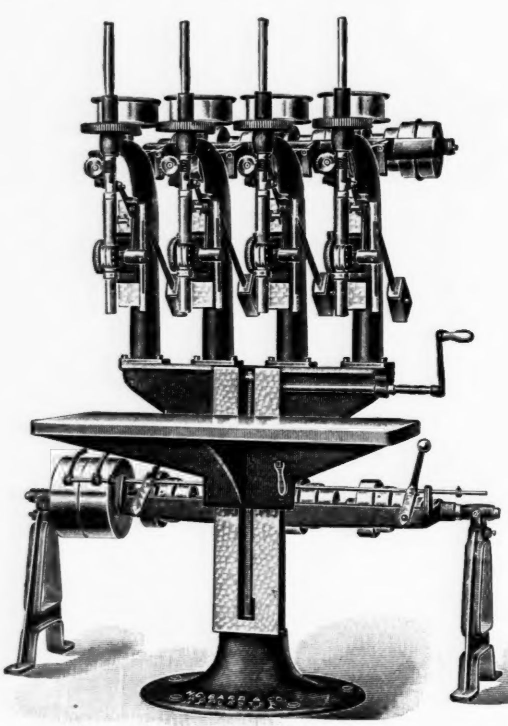
This machine accommodates single or multiple thread worms of any diameter. Right- or left-hand threads are cut by merely setting the tool to the right or left. It is made in two styles: The plain style cuts wormwheels in which the worm is at right angles to the axis of the wormwheel. This style cuts spur gears with the ordinary rotary cutter. The universal style cuts wormwheels to suit worms at any angle to the wheel axis. This style also cuts spiral and spur gears either with the ordinary rotary cutter or with a hob. Six sizes of each style are built, by Eberhardt Brothers Machine Company, of Newark, N. J.

SENSITIVE DRILLING MACHINES.

The use of high-speed drills, together with the modern practice of duplicate jig work, has created a demand for more

powerful machines of the class known as sensitive drilling machines. To meet this demand H. G. Barr, Worcester, Mass., has brought out ten new machines. One of these styles has two, three, four, five and six spindles guaranteed to drill up to ⅝-inch holes in ordinary practice, but not intended for high-speed drills of that size. These have one-inch spindles with ball-bearing thrust collars, the bearings being made of tool steel from the bar. There is a No. 2 Morse taper in the spindles, and three speeds independent to each spindle. The spindles have a traverse of 5 inches. The heads are adjustable and the tables are also adjustable on the columns. The spindles have power feed driven independently from each spindle, also automatic stop and quick return. All the drills have lever feed and power feed, but are furnished without feed, at lower cost, if desired.

Another style is built in five sizes with two, three, four, five and six spindles. It is similar to that described above with the following additional features: The spindle driving pulleys are set on studs back of the spindles and are geared to the spindles with spur gears about 2 to 1, giving sufficient power to drill ¾-inch holes easily with high-speed drills. They will drill holes larger than this but are not warranted to stand continuous use with ⅞-inch drills, or larger, as these sizes are for a heavier class of machines. The tight and loose pulleys on all these machines are 10 inches by 3¾ inches. The manufacturer states that these machines are strong and durable and have been designed with a view to adapting them to



Barr Sensitive Drill.

up-to-date needs and, added to their regular line, make a very complete line of sensitive drilling machines, there being 36 different machines.

GRIDLEY AUTOMATIC TURRET LATHE.

The Windsor Machine Co., Windsor, Vt., have for some time been manufacturing an automatic turret machine for bar work that is a distinct departure from other automatic machines. They have now brought out a machine of entirely new design, embodying the more important features of the earlier machines, but containing a new arrangement of mechanism and tools. In this, as in earlier machines, the tools are fastened to and supported by slides gibbed onto the periphery of the turret which does not move axially, but is mounted to revolve on an axis parallel with the spindle.

In the base of the machine is the horizontal cam shaft containing the drums and disks to which the cam plates or dogs are fastened for actuating the various motions of the machine.

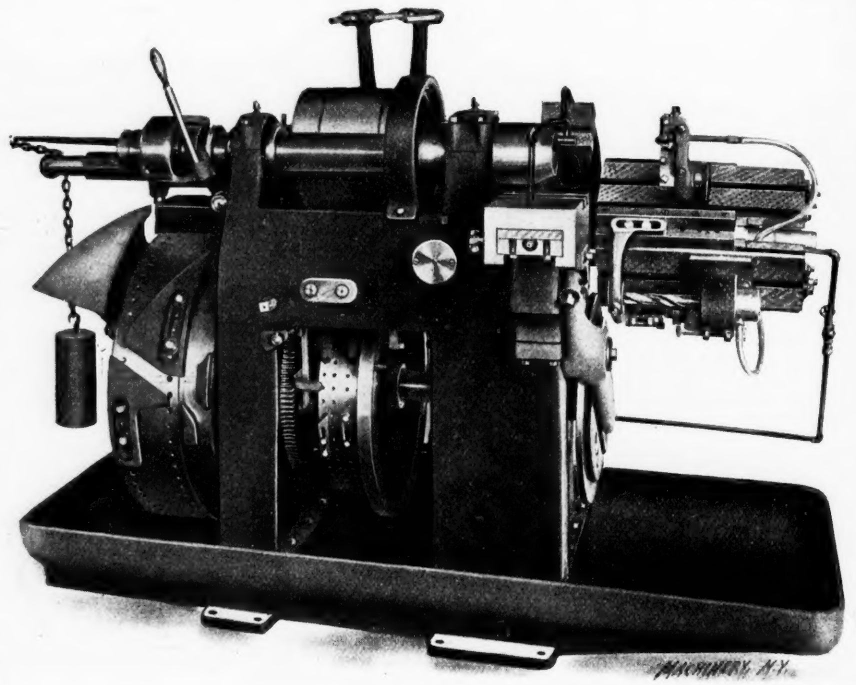


Fig. 1. New Automatic Turret Lathe.

The turret is supported by a hollow spindle running in bearings at each end of the headstock. On this spindle is keyed a wormwheel and an index plate, the latter having four notches corresponding with the four slides of the turret. The wormwheel is driven by a worm on a shaft at right angles to the lathe spindle, and on the rear end of which is the belt pulley which runs continuously. The worm is thrown into or out of action by a clutch mechanism operated by a lever which receives its motion from the drum at the center of the cam shaft. This lever also withdraws a locking pin which fits into the notches in the index plate. The arrangement of the mechanism is such that the pin must be positively withdrawn before the clutch faces come in contact, and also the clutches must be thrown out of contact before the pin can again engage the notches.

The turret slides derive their feed from the large cam plates bolted on the face of the cam wheel at the left of the machine. These plates operate a draw bar extending through the hollow spindle of the turret and engaging a pin attached to the under side of each slide when the slide is brought into position by the rotation of the turret.

The lathe spindle is fitted with a draw chuck operated by cams on the right of the large drum. Inside the sleeve of the draw chuck is a feed tube for feeding the stock through the spindle. This is split at the chuck end of the spindle so as to grip the stock securely enough to feed it forward, but slides over the stock when the chuck is closed on it and the sleeve is drawn backward by the large cam attached to the left-hand side of the large drum. This places the sleeve in position for feeding the stock again under the action of the weight shown in the engraving, after the usual method in such machines.

The cams attached to the face and left-hand side of the small drum at the center of the machine are for shifting the spindle and feed belts. The spindle is back-geared at a ratio of 4 to 1, and is driven by either of two belts—one of which reverses the motion of the spindle when backing out a tap. If automatic dies are provided, however, both belts may run in the same direction, thus making two belt speeds. The disk at the extreme right of the cam shaft carries two sets of cams, one for the cut-off arm and the other for moving the forming

slides, plainly shown in the illustration. Perhaps the chief interest in the machine centers about the novelty of the horizontal turret with its slides, to which are bolted the tools and tool holders. This arrangement enables a great variety of work to be done with comparatively simple tools which are readily adjusted. Much of the work is performed by single-point cutting tools or turners instead of with box tools or forming tools. The turret slides have longitudinal T slots so that the tool holders may be located at any point in the length of

Fig. 2. Turner used on Lathe.

the slide, which fixes their position relatively to the work, while the feed cams determine the time and extent of the movement of the tools.

The half-tone, Fig. 2, shows one of the turners regularly supplied with the machine, which is to be clamped directly to one of the turret slides. This turner carries its own back rest and uses a single-point cutting tool. The back rests shown in place are of the usual type consisting of blocks clamped in position, but roller back rests, such as shown standing beside the turner in the engraving, have been found to give very satisfactory results and to greatly reduce the friction.

In Fig. 3 are details of a cross slide designed to be clamped to one of the turret slides and to be used in turning, by the aid of a former bolted to the turret. This is designed so that the slide carrying the tool withdraws automatically on the return,

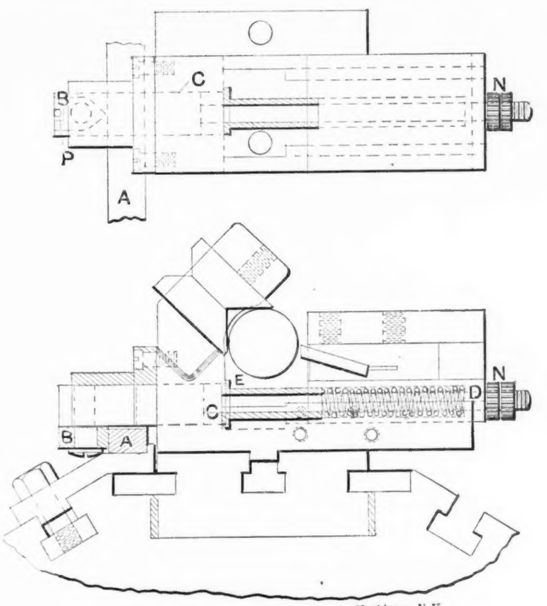


Fig. 3. Tool Slide and Back Rest.

thus preventing the cutting edge from rubbing over the finished work. In the illustration *A* is a guide against which the swivel block *D* pivoted to piece, *C*, bears. Piece *C* extends through the head and is threaded on the end for the nut, *N*. The spring bearing against the slide at *D* and against the bushing at *E*, which at its other end bears against the casting supporting the back rest, tends to continually push the tool away from the work as far as allowed by the position of the nut, *N*, thus taking up all backlash. When the tool begins to cut, the swivel block *B* takes the position shown in the upper view, with the pin, *P*, bearing against one side of the slot. When the tool travels in the other direction, the block swivels slightly until the pin bears against the other side of the slot and allows the spring to force the tool a slight distance away from the surface of the work. Fig. 4 shows a similar device arranged for a fixture containing a boring, turning, and facing tool, and designed primarily for taper work, although the

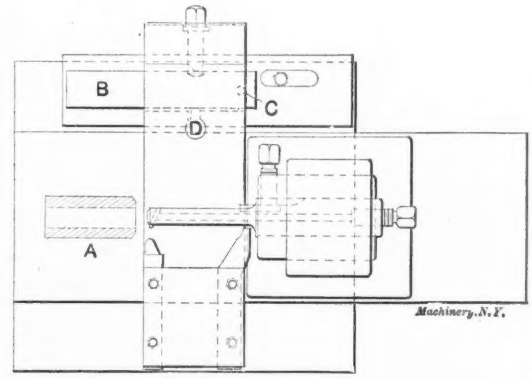


Fig. 4. Taper Turner.

piece shown at *A* is cylindrical. *B* is the former pivoted at *C* to a block attached to the turret. In case taper work were to be done, the outer edge—the upper edge in the engraving—would be the taper surface of the former against which the projecting piece attached to the slide would bear. Against the back or lower side of the former a swivel block, *D*, bears, which is pivoted to the base of the attachment. The purpose of this block is to relieve the tool on the return as in the turner shown in Fig. 3, without in any way affecting the adjustment of the guide bearing against the taper part of the former, which determines the shape of the piece.

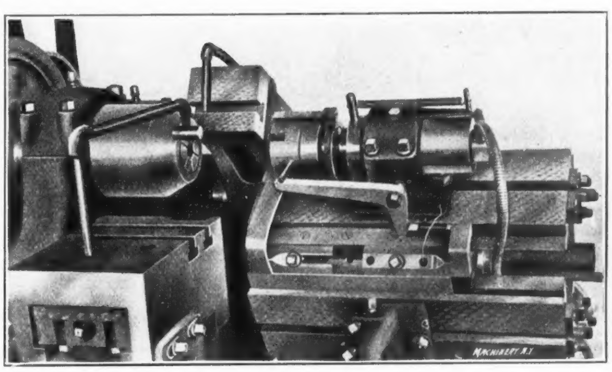


Fig. 5. Geometric Die Fitted to Lathe.

The illustration, Fig. 5, and the line drawing, Fig. 6, show the way in which a Geometric self-opening die is fitted up for use on the machine. As the die advances upon the work lever *B* comes in contact with the stop, as indicated, and opens the die. Upon the return the arm, *C*, of the bell crank lever hits a stop bolted to the lathe turret which throws up the long arm of the lever, hitting pin *A* of the die and closing it.

In Fig. 7 is the drilling attachment, fitted up with a hollow drill. The guide bushing for the drill is carried by an arm

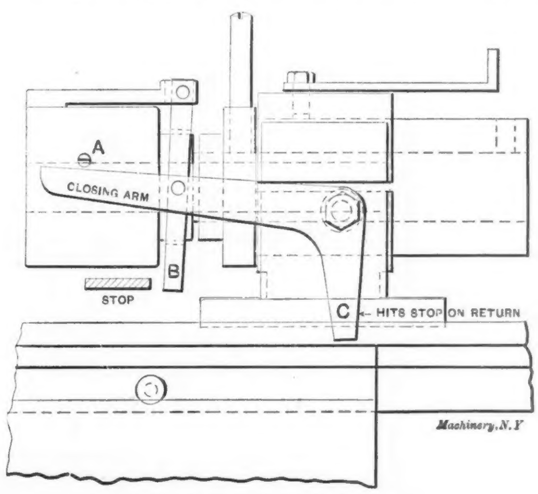


Fig. 6. Details of Die Holder.

bolted to the turret while the drill holder is clamped to one of the turret slides. Oil is carried to the drill by flexible tubing, and the arrangement is such that oil is supplied to this and to the other tools only when the slide carrying each tool

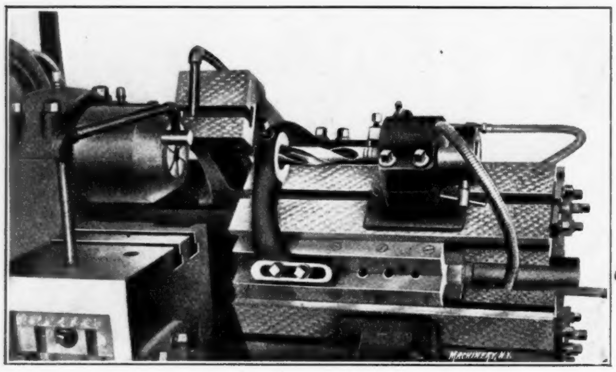
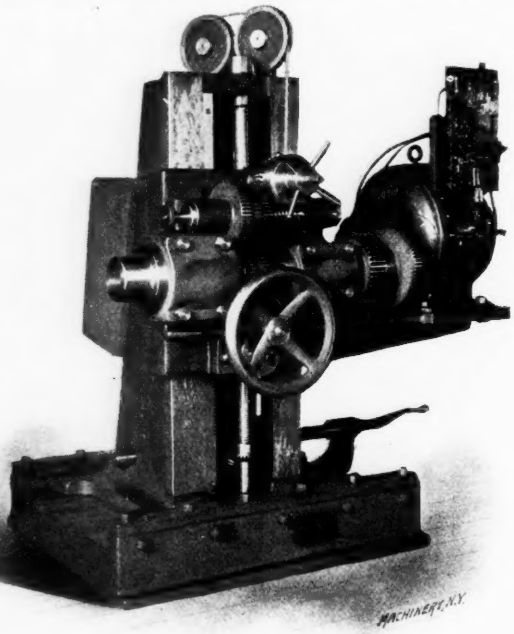


Fig. 7. Drilling Device, Gridley Automatic Turret Lathe.

is in a position where oil is required. In every other position the slide automatically shuts off the supply, so that the oil is not flowing over parts of the machine where it is not desired.

SARGENT MILLING MACHINE.

A special milling machine made by W. L. Sargent, Fitchburg, Mass., is shown in the accompanying illustration. The frame consists of a heavy upright made to travel in ways on the base of the machine. The saddle carrying the working spindle travels vertically on the column and is balanced by a casting supported by a cable at the rear of the column. The machine is driven by an electric motor located on the saddle, so that the machine is self-contained and independent of



Sargent Special Milling Machine.

belts and pulleys. It has power feed in a vertical direction. The feed is driven through a cone of gears and a friction clutch. The principal dimensions of the machine are: Vertical movement of saddle, 20 inches; hole in spindle No. 6 Morse taper. Saddle has power down feed with three changes. Spindle driven by constant speed two H. P. motor, arranged to give suitable speeds by change of pinions. Front spindle bearing 4½ by 8 inches. Size of base 33 by 38 inches. Net weight of machine with motor, 4,200 pounds.

* * *

Some brands of high speed steel are very high in price, but perhaps their cost to the user is not disproportionate to their cost to the maker when we consider the high price of many of the constituents used. For instance, vanadium costs, abroad, about $10 per pound; molybdenum, $1.50; tungsten, 65 cents, and nickel, 35 cents.

FRESH FROM THE PRESS.

MECHANICAL APPLIANCES AND NOVELTIES OF CONSTRUCTION. By Gardner D. Hiscox. Published by the Norman W. Henley Publishing Co., 132 Nassau Street, New York. 396 8vo. pages. Illustrated with nearly 1,000 engravings. Price $3.00.

This is a supplementary volume to the one upon mechanical movements by the same author, which has passed through ten editions. Instead of dealing with elementary movements like the earlier volume, it contains illustrations and short descriptions of many combinations of motions and of mechanical devices and appliances found in different lines of machinery. Some of the chapter headings are: Steam Power Appliances; Hydraulic Power Appliances; Road and Vehical Devices; Horological Time Devices; Textile and Manufacturing Devices; Perpetual Motion; etc. While perpetual motion, of course, is a dream and a fallacy, the historical treatment of the subject in this chapter will prove of interest. The other chapters, however, deal with practical devices. The engravings are all made by the wax process (the same that is employed in MACHINERY) and are unusually well executed. The book will appeal to mechanics, inventors and others who wish to familiarize themselves with interesting mechanical devices covering a wide range of work in many fields.

A SECTIONAL DRAWING OF A MODERN BATTLESHIP WITH REFERENCE LIST OF PARTS. Published by the Derry-Collard Co., New York. Price 50 cents.

This is probably the finest sectional engraving of a mechanical subject that has ever been produced. It shows a longitudinal section of a modern United States navy battleship of the *New Jersey* and *Connecticut* type, completely equipped and supplied with the stores necessary for a sea voyage. The section has been drawn in different planes at different points of the ship, so as to show the interior of all the important compartments into which the hull of a vessel is divided, regardless of whether they are located in the central plane of the boat or at front or back of it. By this means practically everything that goes to make up a battleship and its equipment is shown. There are in all 497 items to which reference is made in the list of parts.

The original drawing from which the engraving was produced is a wash drawing in black and white, the preparation of which extended over a period of two years. The reproduction is nearly 3 feet long, and 13½ inches high. It is printed on heavy plate paper, suitable for framing. Reference to certain details will show the care with which every part has been gone into. Of the machinery equipment, besides the engines and boilers all the auxiliary machinery, such as winches, steering gear, blowers, pumps, etc., are shown and the machine shop and laundry are shown fully equipped, and we note that in the machine shop even the handles of the engine lathe are drawn, so carefully has the artist gone into details. We are informed, moreover, that all these parts are in the correct proportions, as the details represented were carefully measured before being placed on the drawing if their sizes were not known. The method of hoisting the ammunition is indicated, the food supply in the refrigerator is shown, as well as other stores, furniture, etc., etc. Underneath the drawing is a scale by which dimensions of any of the parts can easily be determined. The ships semaphore signals are set, the speed cone has been elevated, indicating "full speed ahead," and the flag signals read: "We can defend ourselves." The drawing was approved by naval officers before the engraving was made.

MANUFACTURERS' NOTES.

THE NEW ENGLAND ROLLER GRATE CO., Springfield, Mass., have decided to open up a store for the sale of machinery, new and second-hand, and shop and foundry supplies, at 218 Worthington St., on the first of December.

THE NORTHERN ELECTRICAL MFG. CO., Madison, Wis., were recently awarded the order of the Cutler Hammer Mfg. Co. for the electric equipment for their works, consisting of a 75 K. W. and a 37.5 K. W. generator

THE BLANCHARD MCHE. CO., Boston, Mass., report that on Nov. 11 their office at No. 11 Harcourt Street, was burned out, there being considerable damage. This, however, will give them an opportunity to secure larger quarters so long needed.

THE CROCKER-WHEELER CO., Ampere, N. J., are distributing a postal card stating that they are supplying the electric light and power plant for the U. S. S. *Connecticut*, which consists of 8 Crocker-Wheeler generators direct-connected to Forbes marine-type engines.

THE BAY STATE EMERY WHEEL CO., Worcester, Mass., have purchased the real and personal properties owned by the National Emery Wheel Co. and will continue the manufacture of corundum and emery wheels by the same processes, and under the supervision of Superintendent H. F. Sanderson.

HENRY E. EBERHARDT, who was identified with Gould & Eberhardt, Newark, N. J., for more than 35 years, as a member of the firm, chief designer and inventor, has resigned from the above company, and is now associated with his sons in the Eberhardt Bros. Machine Co., Newark, N. J

THE NORTHERN ELECTRICAL MFG. CO., Madison, Wis., are equipping the new plant of the 23d Regiment Armory, Brooklyn, with two 75 K. W. "Northern" generators direct-connected to a Harrisburg engine, and with a 35 K. W. "Northern" generator belted to a Nash gas engine.

J. G. BLOUNT CO., Everett, Mass., manufacturers of lathes and grinding machines, have just completed a new storehouse next to their shop, which will give them additional facilities for carrying a larger stock than they have heretofore been able to, so as to fill all orders for their tools on receipt.

THE VITRIFIED WHEEL CO., Westfield, Mass., have recently moved into their new plant. The plant is well lighted and built after approved modern methods. This company manufacture pure corundum wheels for grinding purposes; also vitrified wheels, made of a new crystal corundum.

The McCullough-Dalzell Crucible Co., Pittsburg, Pa., have just completed a new dry house, comprising a series of deep pits, flanked by large furnaces. The drying process is an important factor in crucible making. Natural gas is the fuel used for heat and power. The company report an encouraging growth of new business during the year.

THE BURKE ELECTRIC CO., Erie, Pa., is a new company incorporated under the laws of New Jersey with a capital of $150,000. They have absorbed the Keystone Electric Co. of Erie, Pa., whose plant they will occupy, and are to manufacture dynamos and motors under the patents of James Burke, president of the company. Herbert B. Coho is vice-president and Gustave Faure manager and superintendent.

We have received a letter from the Coes Wrench Co., Worcester, Mass., saying that they have recently been visited by four engineers from Vienna, Austria, who are securing information from American plants, and from conversation with them the Coes Wrench Co., is led to believe that they are attempting to secure points about the manufacture of American hardware, which will be detrimental to the interests of firms selling abroad, where the competition of foreign manufacturers of hardware is very keen.

THE NATIONAL ELECTRIC Co., Milwaukee, Wis., have entered into an important arrangement with Robert Lundell and Robert T. Lozier, by which the National Company will manufacture and market the new motors and generators and systems of operation and control that are covered by the latest inventions of Robert Lundell; the commercial direction of the undertaking being placed in the hands of Robert Lozier, who will also act as general manager of the Electrical Sales Department of the National Company. Mr. Lundell assumes the direct supervision of the engineering involved under the license that he grants the National Company, and which covers all of Mr. Lundell's inventions not already under license to other companies, and all inventions that he may hereafter make during the life of this license.

NEW TRADE LITERATURE.

Manufacturers and others sending catalogues for notice are requested to address them to the Editor of MACHINERY, so that they can be kept separate from catalogues sent us for other purposes.

JAMES MCCREA & Co., Washington St., Chicago, Ill. 1904 catalogue of steam specialties.

THE WHITMAN & BARNES MFG. Co., Chicago, Ill. Illustrated catalogue of haying tools and supplies.

ZEH & HAHNEMANN, 213-219 Chestnut St., Newark, N. J. Circular of this company's inclinable power presses.

THE WESTERN ELECTRIC Co., Chicago, Ill. Bulletin 6010 of knife switches. The various styles of these are here shown and described.

THE COOK MFG. Co., Albion, Mich. Catalogue of gas and gasoline engines. The Cook engine is here described and illustrated in detail.

THE DEAN-WATERMAN Co., Covington, Ky. Catalogue of the "Dean" gas and gasoline engines, built in sizes from 2 to 50 horse power.

THE CROWE METAL MFG. Co., Chicago, Ill. Illustrated catalogue of metal name plates.

THE HENRY WALKE Co., Norfolk, Va. Catalogue H of portable saw-mill machinery and similar specialties, as manufactured by the Curtis & Co. Mfg. Co.

THE EMERSON ELECTRIC Co., St. Louis, Mo. Bulletins Nos. 3060 and 3061 showing bipolar enclosed motors, and friction and bench drills driven by Emerson motors.

THE MECHANICAL APPLIANCE Co., Milwaukee, Wis. Booklet illustrating the "Watson" multipolar motors and generators and their application to various types of machinery.

THE WELLMAN-SEAVER-MORGAN Co., Cleveland, Ohio. Pamphlet descriptive of the Akron Chilian mill designed and built for the wet grinding of metalliferous rock. This is described in detail.

GREENE, TWEED & Co., 17 Murray St., New York. Illustrated catalogue of belt studs, belt couplings, piston and sheet packings, the "Rochester" automatic lubricators, wrenches, the "Colvin" interchangeable hammer, etc.

THE NORTON EMERY WHEEL Co., Worcester, Mass. Leaflet relative to India oil stones. These are regularly made in 34 shapes covering ordinary demands of the trade, but anything special in this line will be made to order.

THE GEM MFG. Co., Pittsburg, Pa. Illustrated catalogue of oilers, torches, flexible shafting, boiler-tube cleaners, loose-pulley lubricators, etc. Also circular of the Nos. 1 and 2 Impulse water-tube boiler cleaners.

THE MANHATTAN ELECTRICAL SUPPLY Co., 32 Cortlandt St., New York. Circular of the Hubbell shade holder which, it is stated, is simple in design, strong, durable and holds the shade rigidly without chance of its loosening.

THE CHARLES E. WRIGHT Co., New Orange, N. J. Catalogues of saw machinery. Catalogue "A" takes up band and circular saws; another, wood and metal band sawing machinery and a third takes up cold metal cutting.

THE FALLS RIVET & MACHINE Co., Cuyahoga Falls, Ohio. Illustrated catalogue of the Wadsworth improved core machine, making 24 sizes of round cores from 3/8 to 6 inches; also, square, hexagon D and irregular shapes.

THE C. W. HUNT Co., West New Brighton, N. Y. Catalogues Nos. 046 and 047. The first treats of electric hoists, winches, capstans, the different styles of which are here shown; the second describes coal-handling machinery.

THE FRITZ & GOELDEL MFG. Co., Grand Rapids, Mich. Illustrated catalogue of drafting room and office furniture, including several styles of drafting tables, drawing boards, blueprint frames, office desks and typewriter desks, railroad filing cases, etc.

THE COBURN TROLLEY TRACK MFG. Co., Holyoke, Mass. Booklet calling attention to the Coburn trolley track for carrying materials on an overhead track and saving time and labor. Their No. 20 catalogue gives complete details and will be sent on request.

THE VILTER MFG. Co., Milwaukee, Wis. Catalogues of refrigerating and ice-making machinery; of horizontal Corliss engines; of steam boilers; of buildings for breweries, bottling and ice-making plants (Catalogue C); and of bottlers' machinery and supplies.

THE INGERSOLL-SERGEANT DRILL Co., New York. Form 341, "Driving the New York Subway, a short history of this great enterprise, mentioning incidentally the part played by this company's rock drills and air compressors in the construction of the subway.

J. M. CARPENTER TAP & DIE Co., Pawtucket, R. I. New catalogue, No. 16, and price list of taps, dies, hobs reamers, screw plates, pipe stocks and dies, tap wrenches, etc. They call attention to their very complete list of their round die sets to be here found.

THE INGERSOLL-SERGEANT DRILL Co., New York. Pamphlet, "The Storage Air Brake System of the St. Louis Transit Co.," containing a short sketch of this system and referring to the tests of the system made by the Railway Test Commission at the St. Louis Fair.

THE COLBURN MACHINE TOOL Co., Franklin, Pa. Catalogue "A" of the Colburn universal saw table. This was described in MACHINERY, July, 1903; also illustrated pamphlet relative to their 72-inch widened pattern vertical boring mill, described elsewhere in this issue.

THE AMERICAN STEAM PUMP Co., Battle Creek, Mich. Illustrated catalogue No. 12 of the Marsh steam pumps. Boiler feed pumps, plunger pumps, marine pumps, yacht pumps, tank pumps, vacuum pumps are shown. Also air compressors, deep well pumping engines, etc.

THE AMERICAN BLOWER Co., Detroit, Mich. Bulletin No. 171, descriptive of a new product—the "A B C" type vertical, enclosed, self-oiling engine. The oiling system is fully described and the engine is illustrated by a number of half-tones showing the different types and details.

THE BAYLDON MACHINE & TOOL Co., Jersey City, N. J. Advertising card in the shape of an emery disk, calling attention to the company's disk grinders and showing their No. 20 disk grinder, which they state is a reliable machine and furnished at a very low price for a good disk grinder.

THE SPRAGUE ELECTRIC Co., New York. Bulletin No. 218 showing some of the applications of the Sprague electric motors. These are shown driving radial drills, planers, die presses, various styles of pumps and other machinery. The Sprague electric hoists, worm and spur-geared, and an electric winch also appear.

THE CHANDLER PLANER Co., Ayer, Mass. Illustrated catalogue containing description of the Chandler planer which, with the use of high-speed steels, runs at a cutting speed of 60 feet per minute, returning at 200 feet per minute. A complete description of this tool was published in MACHINERY, July, 1904, number.

THE EVANS FRICTION CONE Co., Newton Center, Mass. 1904 catalogue of the Evans friction cone. Hanging patterns Nos. 5, 6 and 9 are shown and standing pattern No. 9, the first for driving machinery from overhead and the other from the floor. The rest of the booklet is devoted to a very large list of users of this style of drive.

THE JOSEPH DIXON CRUCIBLE Co., Jersey City, N. J. Twenty-four-page booklet on the subject of graphite for lubricating automobiles and motor boats. The lubricants here described are just for this special class of machinery and the booklet will prove useful to those interested in motor cars and motor boats, to whom a copy will be sent free.

THE COLUMBUS MACHINE Co., Columbus, O. Special catalogue, 1904, of gas and gasoline engines. In addition to their regular line, shown in their previous catalogue, they here illustrate a geared pumping engine and a hoisting engine, recently put on the market. Also a traction engine for agricultural purposes. A list of sizes is also to be found.

THE GARVIN MACHINE Co., New York. Booklet descriptive of the solid extended knee which is a prominent feature of the Garvin milling machines. There are no openings either in top or sides, which adds to its stiffness and solidity and makes its use specially desirable for heavy work, obviating chattering. The knee is here fully described.

THE MONARCH ENGINEERING & MFG. Co., Baltimore, Md. Pamphlet describing the Steele-Harvey metal melting and refining furnace. It consists of an outer steel shell, lined with a double row of firebrick into which fits the crucible. The furnace can be tilted at any angle and the crucible being always within the furnace loses no heat in cooling off.

THE CARBORUNDUM Co., Niagara Falls, N. Y. "This Land of Ours," an attractive pamphlet giving interesting historical matter relative to this country generally and in particular about the plant of the above company where carborundum is made. The many and various uses to which carborundum may be put, are here enumerated and illustrations shown.

THE SAWYER TOOL MFG. Co., Fitchburg, Mass. Circular showing the company's new line of friction joint calipers (patent applied for). These are outside and inside calipers, and hermaphrodite calipers whose joints have pockets for holding the beeswax for an indefinite period. The joints are adjustable for any desired tension. Complete catalogue furnished free.

THE TURNER, VAUGHN & TAYLOR Co., Cuyahoga Falls, Ohio. Loose leaf catalogue of the company's products. These include core machines; steel and cast-iron tub beaters and rubber washers for removing sand, etc.; roll pointers; wire-drawing machines; the Chaser clay mills, double-acting steam press; chain link cutters and winders; oil and gas-burning furnaces, etc.

THE ALCOLM Co., 200 Broadway, New York. Initial edition of the New York Business Telephone Directory, a copy of which is delivered for every telephone in Manhattan and the Bronx. This enables one to find promptly business addresses and those of professional men, lawyers, doctors, etc. Private addresses are entirely eliminated and the addresses given are classified according to the business or profession. The book will be published twice a year.

THE ABENDROTH & ROOT MFG. Co., Newburg, N. Y. Catalogue (with discount sheet) of pipe, spiral riveted, straight seam and punched; and of formed sheets for making up at destination. Different samples of this pipe are shown and quite a number of views of its installation, with testimonials of its efficiency and durability. A number of tables appear and the new style of Root exhaust head is shown. The company also manufacture the Root water-tube boilers, elevators, bilge pumps, flumes, etc.

THE NORTON EMERY WHEEL Co., Worcester, Mass. Catalogue of emery and corundum goods and grinding machinery. This book contains 167 pages and appears to be very complete; emery cylinder chucks, bench grinding machinery, floor grinding machinery, the Norton bench tool grinders, countershafts, a lathe grinding attachment, etc., are described. The Norton Co. no longer manufacture or sell the Walker universal tool and cutter grinder but are prepared to furnish a universal tool and cutter grinder, in two sizes, which they can recommend to the trade.

THE JOHN M. ROGERS BOAT, GAUGE & DRILL WORKS, Gloucester City, N. J. Catalogue No. 7, of small tools. These include fixed caliper and internal and external cylindrical gages and limit gages; measuring machines; corrective gage standards (disks for correcting fixed gages, for setting calipers), etc.; reamers, in many varieties — taper, shell, pipe, inserted-blade, spiral-fluted, adjustable-bladed, etc.; rose reamers, hand reamers, and chucking reamers; and a special adjustable milling tool for milling, facing and centering work in one operation. A number of useful tables also appear.

THE A. S. CAMERON STEAM PUMP WORKS, New York City. Miniature catalogue of steam pumps, a reproduction in part of their complete catalogue. This neat little pamphlet presents a few designs of the Cameron pumps, viz., steam pump for regular service; boiler feed pump; automatic feed pump and receiver; light service pump, with removable bushing; single compound; air pump and condenser; plunger pump; mining pump; sinking pump, etc. The advantages claimed for this pump are simplicity, due to the small number of working parts; and durability, the steam mechanism consisting of four stout pieces only.

THE STANDARD WELDING Co., Cleveland, Ohio. "Welding Simplicity" —booklet telling what this company does in the matter of electric welding. Mention is made of some apparently impossible jobs which have been successfully done by this method. As an example, seamless steel boiler flues 4 inches in diameter have been welded together to make 30-foot tubes; a pile of bands 14 inches wide 10 feet long and 1-16 inch thick are welded into a continuous belt, a hard steel sprocket shaft is welded to a steel casting, for use as a brake drum on an automobile, etc. The company state that by their method of electric welding work is done with far less expense and greater effectiveness. The book is sent free upon request.

THE NORMAN W. HENLEY PUBLISHING Co., 132 Nassau St., New York. Catalogue 9 x 12 of technical books. This is a list of up-to-date works on the following subjects: Tool making and interchangeable manufacturing; gas engines; dies; the treatment of steel; compressed air; machine shop tools, patternmaking; perspective drawing; saw filing; liquid air; automobiles; the steam engine; the locomotive, etc., etc. Among them we note as nearly ready: "Gas Engines and Producer Gas Plants, by R. E. Mathot, covering the subject of the gas engine; and "American Lathe Practice," by W. H. Vandervoort, embracing the latest practice in lathe and boring mill operations. Each book mentioned is the work of a man experienced on the subject of which he writes, and is therefore reliable and valuable. A good description of the works appears in this catalogue, to serve as a guide

in the selection of them. This catalogue, and their 114-page catalogue of practical books, will be furnished upon request.

CHARLES H. BESLY & Co., 15-21 South Clinton Street, Chicago, Ill. Illustrated catalogue, 1904, of the Gardner grinders, spiral groove disk wheels. Besly band grinders, etc., also of band polishing machines, Helmet cement, Helmet oil, Badger oil cups, and other specialties. The principle of the Gardner grinder and the spiral-groove disk wheel (an essential feature of this tool) are here described, and full directions given as to the methods of operating same. Nine new machines are shown and also two styles of motor-driven Gardner disk grinders, on which can be used any of the well-known makes of motors. A number of pages are devoted to illustrations of the various operations that can be rapidly performed with this tool, such as: Finishing malleable iron wrenches on a No. 6 grinder at the rate of 75 wrenches per hour; grinding a casting (a case for a toothed steering quadrant for automobile) in 90 seconds; grinding 8-inch forgings both sides in 45 minutes, etc. Specifications and prices of each style and size of grinder are to be found, also a good number of testimonials, by users of this tool, expressing their entire satisfaction. The Gardner grinder is used for a great variety of work—grinding and finishing leather, wood, hard rubber, steel, drop forgings, brass, copper, aluminum, cast iron, and an instance is given of a Gardner grinder being used in a marble works for grinding tops of mantelpieces.

ST. LOUIS AWARDS.

The Gisholt Machine Co., Madison, Wis., have been awarded the grand prize at the Louisiana Purchase Exposition.

The E. W. Bliss Co., Brooklyn, N. Y., have received the grand prize and gold medal for tools and machines exhibited at St. Louis.

The Electric Controller & Supply Co., Cleveland, O., announce that they have been awarded the gold medal for their St. Louis World's Fair exhibit.

The Norton Emery Wheel Co., Worcester, Mass., received the grand prize for their grinding machinery at the St. Louis Exposition, also two gold medals for other products exhibited by them.

The Goldschmidt Thermit Co., New York, were awarded the grand prize at St. Louis for their welding compound, thermit; also the Elliott-Cresson medal, which was conferred on them by Franklin Institute.

The Keuffel & Esser Co., New York, have received the highest award at the St. Louis Exposition—the only grand prize for Group 19 (instruments of precision, philosophical apparatus, etc), and a gold medal, for Group 115, instruments and equipments for underground surveying.

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In a paper read before the Coventry Engineering Society, Mr. J. M. Gledhill outlines the process of making shear steel as follows: Five short lengths of blister bar are heated in a hollow coke fire, and which by use of a soft blast admits of being regulated to a welding heat. During this time the surface of the bars is covered with clay beaten fine and applied during the heating to exclude the air and prevent oxidation. The bars are then carefully hammered and welded together. This is known as "single shear" steel. To make "single shear" into what is known as "double shear" steel the bar made of "single shear" as above described is broken in the middle, the two pieces laid together, welded a second time and again drawn to the required shape. By this double operation the steel becomes more homogeneous and of a finer texture, and we thus obtain a material having a hard and steely exterior, and yet possessing a soft interior, thus securing both hardness and ductility where required.

MISCELLANEOUS.

Advertisements in this column, 25 cents a line, ten words to a line. The money should be sent with the order.